Alfred Trower
with the best wishes
of his sincere friend
Charles Robert Alexander

On his leaving Eton
Xmas 1866.

ELEMENTS

OF

PRACTICAL AGRICULTURE;

COMPREHENDING THE

CULTIVATION OF PLANTS, THE HUSBANDRY OF THE DOMESTIC ANIMALS, AND THE ECONOMY OF THE FARM.

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PREFACE.

The Agriculture of a country is affected, in its general character and details of practice, by climate, the fertility of the soil, and the food and habits of the people. It is climate which determines the plants to be cultivated, and the order of the labours of the season, and which modifies all the practices of the husbandman. Even within no great extremes of temperature, the practice of the farmer must be varied to suit the differences of climate. Thus, the agriculture of the south of France is not the same as that which is established in Normandy and other departments of the North; and in Italy, where, along with the productions of northern climates, are cultivated the rice, the maize, the Indian millet, and other plants of warmer regions, the agriculture differs in many parts of practice from that of the corn-exporting countries of the north of Europe.

To treat of agriculture, therefore, as a practical art, without reference to some given conditions of climate and country, would embrace a wide range of observations and

the consideration of a great mass of details. It would involve the examination of many opposite practices, in themselves perhaps good and adapted to the circumstances which give rise to them, but, as a whole, unsuited to any one condition in which the farmer could be placed, and thence incapable of being reduced to practice. That instructions in agriculture, therefore, may avail for useful purposes, they must have reference to a system applicable to some given condition of climate and country. In this way the study will be rendered more easy to those who enter upon it for the first time; and not only will the student make the most rapid progress, but he will acquire the most useful species of knowledge. For, however different be the natural productions of countries, and however necessary it be that the farmer adapt his operations to these differences, yet there are rules and maxims in the art common to the husbandry of all countries; and he who is thoroughly acquainted with one good system of practice applicable to any one situation of the farmer, has the means, by an easy analogy, of applying his knowledge to other and dissimilar cases. A person thoroughly trained to practice on the banks of the Tweed, will make a good farmer on the banks of the Po or the Ohio. He has received the kind of instruction which is useful under all circumstances, and quickly learns to adapt his details of practice to the new circumstances under which they are to be applied.

In describing a system of agriculture, too, it is important that, while it is one which admits of being carried into easy effect, it shall be as perfect as, under this ne-

cessary condition, it can be rendered. A rude system of practice will not serve the purpose of useful example. Although the agriculturist may not be able to reach in all things the model proposed to him, it is yet important that this model be good in itself, so that his own practice may become as perfect as the circumstances in which he is placed will allow.

Agriculture, like every art, is founded upon principles, and a natural method of studying it would seem to be, to begin with principles, and from these to deduce the rules of practice. But the principles laid down must be those of Agriculture itself, and consistent with the results which observation and experience have established. It is rather with the conclusions arrived at, than with the trains of investigation which the sciences themselves involve, that the practical farmer is concerned. Agriculture, like all the arts, is fitted to derive aid from the sciences; and it were an error to suppose, that it is to any one of the sciences exclusively that it can be indebted. Mechanical knowledge, applied to the construction of machines and rural works, has eminently contributed to the advancement of the practical art: Botany and Vegetable Physiology teach us the structure, properties, and uses of plants, and may be rendered in a high degree serviceable in practice: Natural History points out many interesting subjects of reflection and study to the agriculturist: Animal Physiology and Medical Science have relation to the forms of animals, their properties and diseases: and Chemistry is in an especial degree fitted to investigate the nature and constitution of

soils, and the uses and modes of action of manures. Yet a knowledge, however perfect, of any one, or of all, of these sciences together, will not enable us to cultivate a farm, or even a single field. The knowledge required for this purpose is Agricultural, and embraces a series of facts and deductions proper to agriculture itself. Hence it is well, in the study of agriculture, to direct attention especially to the knowledge of what is Agricultural; and it is not to invert the natural order of study, to begin with the acquisition of this species of knowledge. In this way the student will acquire the information which is really essential to him, and without which he cannot be a farmer at all. Should he desire to extend the range of his observation to the relation of different sciences with the practical art, he will do so far more easily, and with less hazard of error, than if he were deficient in this fundamental knowledge.

The following Work was designed as a text-book for students of agriculture, and hence only touches on many subjects which a more extended course of academical instruction affords the means of more fully explaining. I have, however, endeavoured to render the work complete, in so far as the plan of it extends, as a distinct Treatise on Agriculture, and have, in an especial manner, adapted it to those who are to engage in the study for the first time. I have observed the plan of instruction to which reference has been made. One condition of climate and country is assumed, and there is explained, in so far as the limits of the work will allow, a system of agriculture which is conceived to be good, which is founded on ex-

perience, and which is capable of being reduced to practice. It does not, therefore, consist with the design of the work to detail a number of practices, or examine a number of opinions, many of which may be good, and yet not in accordance with the system to be explained. Further, attention is especially directed to the essential points of practice, and while the connexion of agriculture with other branches of knowledge is carefully pointed out, this, in most cases, is done rather to shew that connexion, and to make use of the explanations which it supplies, than for the purpose of entering into investigations not entirely agricultural, and which would extend the Work beyond the limits which would consist with the utility of an Elementary Treatise. I have, however, treated, in such detail as the nature of my work will allow, of the Soil, of the external agents which influence it, and especially of the nature of those substances which, added to it, increase its productive powers, and which we term Manures. Public attention has been particularly directed to this subject, which is highly to be approved of and encouraged. But we must be careful that we do not generalize faster than our actual knowledge will warrant, and substitute theories for the application of known truths, in the vain hope of instructing the farmer and improving agriculture. We may be assured that agriculture will partake of the advantages which science and advancing knowledge are calculated to afford. But we may retard and not hasten this result, if we urge our pace too precipitately, and do not consider truly the nature of the art which we seek to improve, and the necessary limita-

tions under which our principles must be applied in the practice of the farm. While no one ought to doubt, that agriculture will be improved by the application to it of the means which other branches of knowledge supply, it might mislead the practical farmer were we to hold out the hope of our being able suddenly to open for him a short road to the cultivation and improvement of an art, which, more than any other, demands the application of steady labour, economy of means, and practical skill in all its details. Of all the sciences, Chemistry is that which may seem to have the most immediate relation to Agriculture, as affording means of adding to the fertility of the ground, through the medium of the foreign substances applied to it; but, even in the case of Chemistry, a certain degree of caution is necessary in the application of the conclusions of the laboratory to the practice of the fields. It is not precisely with Agriculture as it is with those manufactories, to which this interesting science has been applied with such signal benefits. In the case of manufactories, the substances acted upon are entirely within our control, and we can subject them to the direct influence of the chemical agents we employ. But it is different with the living plants which it is our province to cultivate. We can only trace obscurely the causes which influence their growth and development, and can only imperfectly modify the effects of the external agents to which they are subjected. In applying, therefore, to the culture of the garden and field, the conclusions at which we may have arrived by means of the experiments of the laboratory, we must be careful not to over-

step the limits prescribed by a sound and profitable practice. Thus, it is not enough that the farmer shall be able to communicate a sudden fertility to his ground,—as by the application of such substances as the Alkaline Salts. He must keep his land productive, and if possible increasing in productiveness, so as to sustain a more or less lengthened rotation of crops with the least expenditure. This remark is not designed to discourage the employment of this class of substances, to the more extended use of which the farmers of the country have been gradually conducted by the diminished cost of production, and the increasing refuse which our numerous manufactories afford. It is beyond a question that several of these substances are calculated to afford valuable subsidiary manures to the farmer, and so to add to the general resources of agriculture. But we must be careful that we do not draw erroneous conclusions from our own experiments, or lead the farmer into errors of practice by presenting to him conclusions not sufficiently warranted. Various interesting experiments have been recorded with the Alkaline Salts, and thence their superiority has been sometimes too hastily inferred over manures more accessible to the farmer. Now, the knowledge of this class of substances is nothing new to the farmers of this and other countries. One of them, Nitrate of Potash, or Saltpetre, which is amongst the most powerful of the class, was known to the ancients, and has been partially used by the farmers of England for more than a century. When this substance is tried experimentally in competition with farm-yard dung, with reference to the effects upon any crop,

the balance would seem to be all in favour of the stronger application. But it is manifest, that, in such a case, an essential element of the experiment is omitted, namely, the permanence of the effect. Farm-yard manure, the produce of the farm itself, and on this account alone the most valuable of any manure to the farmer, has an effect which is calculated to last for at least a course of crops, while the effects of the alkaline salt are little perceptible beyond the season in which it is used. When the same substance is tried in competition with Lime, the conclusion would seem to be, that it was amongst the most useful of manures, and that the lime was comparatively worthless. Yet, while the salt exerts an action so transient, the lime may act for the period of an entire lease, and add to the permanent fertility of the soil and farm. These remarks apply to the more powerful salts used in their separate state, or mixed together, and not to such substances as Bones and Guano, which are animal manures, or to Rape-Dust and other vegetable products, our knowledge of all of which has been derived, like that of farm-yard dung itself, not from the analyses of the laboratory, but from experiments in the fields.

The subject of the Domesticated Animals is one of great interest in the rural economy of this country. It may be said that half the rental of the land of the British Islands is derived from the produce of live-stock; and everywhere, the profit of the farmer greatly depends on the care and skill with which this branch of industry is conducted. To have pursued the subject in all its details would have far exceeded the limits of a work designed for

those who begin the study of agriculture. Several years ago, I presented to the public an extensive Work, containing coloured plates, with copious letterpress, illustrative of the various races of the Domesticated Animals naturalized in the British Islands; and since then I have published a Work, more accessible to the farmers and breeders of the country, containing an account of all the Races or Breeds of these Animals, which are the subjects of cultivation in this country, with a description of the properties of External Form, and observations on the Principles and Practice of Breeding.*

Another and extensive department of Rural Economy relates to the Management of Landed Property, the construction of buildings, fences, drains, roads, watered meadows, and other works; the culture of forest-trees, and the management of woodland; the products of mines, and the working of minerals; the subject of rents and the lease; and generally the relations between landlord and tenant. I have treated of some of these subjects in the present volume, but have devoted another work expressly to this branch of rural industry.†

It has been objected to some of the calculations contained in the present Work, that the rate of labour assumed will not apply to a great part of England. This

* On the Domesticated Animals of the British Islands; comprehending the Natural and Economical History of Species and Varieties; the Description of the Properties of External Form; and Observations on the Principles and Practice of Breeding. 8vo. Longman, Brown, Green, and Longmans, London.

† On Landed Property and the Economy of Estates; comprehending the Relation of Landlord and Tenant, and the Principles and Forms of Leases—Farm Buildings, Enclosures, Drains, Embankments, Roads, and other Rural Works—Minerals—and Woods. 8vo. Longman, Brown, Green, and Longmans, London.

objection is good in the case of various districts of very stiff aluminous, or alumino-calcareous, soils in the south-eastern counties of England, where more than the labour of two horses may be required for ordinary tillage; but it does not apply to the greater part of the land of Great Britain. The System of Agriculture here explained, in so far as it regards the methods of farm-labour, has been long established in the north of England, and over all the better cultivated districts of Scotland. In the county of Northumberland, where a system of cultivation is pursued which may serve as a model to every part of this kingdom, the stiffest soils are managed by two-horse teams. While I must admit, then, the exceptions which exist in the case of certain tracts of country, as the London clay, the weald clay, and other very tenacious soils, I maintain that the system of farm-labour here described is capable of being reduced to practice over by far the greater part of England; and that to the whole of Ireland it is applicable in its minutest details. The greatest obstacle to the progress of agricultural improvement is the prejudice of habit. Throughout all England there are agriculturists surpassed by none in the world for intelligence and spirit, and many things in the agriculture of the country are deserving of the highest praise; but it is certain, that, in the simplifying and economizing of labour, there is much to be learned and effected. It is in this respect, that the methods of English tillage, and especially in the southern and midland counties, admit of the greatest improvement. By a more efficient application of the means of labour, a wide field of beneficial improve-

ment is open over a great part of this rich and beautiful country; and one of the most useful services that can be rendered to the farmers of many of the finest districts of England, is to shew them how the operations of the field can be more cheaply performed. It is known, that, in the parts of this kingdom which are the least favoured by nature, the art of tillage has become more perfect by being rendered more efficient and simple; and the result is shewn in the greater revenue derived from land under all the disadvantages of a colder, moister, and more changeable climate. The agriculturists in the south of England are surprised at the high rents paid from the poorer soils in the northern parts of the kingdom. This doubtless arises from a combination of causes; but not the least important of these is a simpler, cheaper, and more effective system of farm-labour.

I have only further to observe, with respect to the present as to the former Editions, that I have made use of portions of a few essays written by me many years ago in the Quarterly Journal of Agriculture; the principal of which are,—descriptions of soils, of the plough, of the harrow, and other implements of the farm; accounts of the turnip-culture, and of irrigation; the subject of the lease, and a few of minor interest.

ERRATA.

Page 35, line 5, *for* wealdens *read* wealden
... 50, ... 14, *for* March Bent-grass *read* Marsh Bent-grass
... 79, ... 7, *for* expressly *read* correctly
... 301, ... 8, *for* economy or manures *read* economy of manures
... 451, ... 9, *for* Isatus tinctoria *read* Isatis tinctoria
... 498, ... 37, *for* Prunus Aucuparia *read* Pyrus Aucuparia

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I. SOILS.

The Weights and Measures referred to are the standard English acre, containing 4840 square yards; the gallon, consisting of 277·274 cubic inches; the pound avoirdupois; and the stone of 14 lb.

ELEMENTS

OF

PRACTICAL AGRICULTURE.

I. SOILS.

I. THE CLASSES OF SOILS, AND THEIR PROPERTIES, AS DETERMINED BY PHYSICAL CHARACTERS.

THE soil is the upper portion of the ground in which plants are produced. It forms a stratum of from a few inches to a foot or more in depth. It is usually somewhat dark in colour, arising chiefly from the carbonaceous matter of the stems, leaves, and other parts of plants which had grown upon it. It is this mixture of the substance of organic bodies with the mineral matter of the upper stratum which mainly distinguishes this stratum from the subjacent mass of earth or rock to which the term Subsoil is applied.

Soils are exceedingly various in their fertility and texture. With relation to their powers of producing useful plants, they may be termed rich, or poor; with relation to their texture, they may be termed stiff, or free. The stiff soils are those which are tenacious and cohesive in their parts; the free soils, likewise termed light soils, are those which are of a looser texture, and whose parts are easily separated. But the cohesive soils pass into the loose by im-

perceptible gradations, and hence, though all soils may be termed rich or poor, stiff or free, they are so in every degree of fertility and texture.

All soils which possess this tenacious or cohesive property in a considerable degree, are termed *clays;* while all the looser soils are termed *light* or *free:* and all soils are more or less clayey, or more or less free, in proportion as they possess more or less of this tenacious and cohesive property, or of this looser texture.

When soils are naturally of good texture and fertile, or are rendered permanently so by art, they are frequently termed *loams:* Thus, there are clayey loams and sandy loams; and peat itself may, by the application of labour and art, be converted into loam.

The parts of plants which grow upon the surface, and are mixed with the mineral matter of the soil, may decompose, and become mixed with it. Under certain circumstances, however, the plants which have grown upon the surface do not entirely decompose, but undergo a peculiar change, which fits them to resist decomposition. They are converted into peat, and the soils formed of this substance are termed *peaty.* The soils derived from peat are of the lighter class, and are distinguished from all others by peculiar characters.

Soils, then, may be distinguished from one another—

1. By their texture, in which case they may be divided into two classes;—1*st,* The stiff, denominated clays; 2*d,* The light or free.

2. By their fertility, or powers of producing useful plants, in which case they are termed rich or poor.

Soils, too, from particular causes, may either be habitually wet or dry, and may therefore be further distinguished by their general relation to moisture. When water, from any cause, is generally abundant, the soils may be termed wet; when there is habitual deficiency of water, they may be termed dry. But this is a condition of the soil, which may arise from causes extrinsic to the nature of the soil.

Subsoils, it has been said, are distinguished from soils properly so termed, by the comparative absence of matter of organic origin. Plants, in growing, may extend their roots into the subsoil, and, decomposing there, be mixed with it, or the soluble matters of the

upper stratum may be washed into the subsoil. But, for the most part, the subsoil is readily distinguishable by the eye from the upper stratum or soil, by the darker colour communicated to the latter by the foreign matter with which it has been mixed.

Subsoils are, for the most part, similar in their mineral composition to the soils which rest upon them, the soil being merely the matter of the subsoil altered by the action of the air, and by the carbonaceous and other matters mixed with it: but frequently subsoils differ both in mineral composition and texture from the soil, as when a stratum of clay rests upon chalk, peat or clay upon sand, or sand upon clay.

Subsoils may either consist of loose earthy matter like the soil, or of rock. Subsoils, therefore, may be divided into two classes, —the earthy and the rocky.

When subsoils contain much clay, they are more or less close, and retentive of water; when they consist of very hard rocks, as quartz, they are in like manner little pervious to fluids; but certain rocks, as chalk and partially decomposed limestones, do not greatly resist the passage of water, and may therefore be classed with the free or porous subsoils.

Whether the subsoil be retentive or porous, the soil which rests upon it should be of good depth, the depth of a soil being itself an index of its fertility. Further, if the soil be shallow on a retentive subsoil, it is affected too greatly by the alternations of dryness and moisture: and if, again, a shallow soil rest on a porous subsoil, the moisture of the soil is too easily acted upon and exhausted by heat.

A subsoil, in so far as mere texture is concerned, should be neither too retentive nor too porous. But although this intermediate condition is in most cases the best, yet in a very cold and moist country, a somewhat free or porous subsoil is for the most part to be preferred to one which is close and retentive. The soil, besides being affected by the texture of the subsoil, is affected by the nature of the mineral substances of which the subsoil is formed.

If the subsoil be rocky, it is desirable that it be calcareous rather

than siliceous,—chalk or limestone for example, rather than quartz. Sometimes the subsoil contains matter which is injurious to the growth of plants. This matter is generally found to be metallic, as iron or copper in certain combinations. Subsoils of this kind are frequently distinguished by deepness of colour.

Soils, then, it is seen, are affected in their properties not only by their own texture and composition, but by the texture and composition of the subsoil; and they are divided into the Stiff or Clayey, and the Light or Free.

The distinguishing characteristic of the Clayey Soils consists in the adhesiveness of their parts; and this property alone will enable even the inexperienced to discriminate them. A stiff clay, when dried either by natural or artificial heat, becomes so hard as to resist a considerable mechanical pressure. On account of the tenacity of such soils, they are tilled with more difficulty than the freer soils. They require, to fertilize them, a larger quantity of manures; but they retain the effects of these manures for a longer time. They are better suited to the cultivation of plants with fibrous roots than of those with fleshy roots or tubers.

Soils of this class, as of every other, possess many degrees of natural fertility. The poorer clays form, for the most part, an unprofitable soil, because, while their powers of production are inconsiderable, the expense of tilling them is great. The clayey soils of this character are generally of little depth, and rest upon a retentive subsoil, similar in composition to the soil. The natural herbage they produce is coarse and little nutritious, and they are not well suited to the production of the cultivated grasses and other herbage-plants. They are little fitted for the growth of turnips, or other plants with large roots or tubers. Such soils have everywhere local names which sufficiently denote their qualities. They are termed, by not an improper figure, *cold* soils; and sometimes they are classed under the general name *moor*, which term is often used to denote soils, whatever be their nature, of a low degree of fertility.

Very different in their value and nature are the richer clays. These bear weighty crops of all the cultivated kinds of corn.

They do not excel the better soils of other classes so greatly in the production of oats, and still less in that of barley, in which respect the lighter loams may surpass them; but they are unequalled for the production of wheat, and, in many places, derive their distinctive appellation from that circumstance, being termed *wheat* soils. They are well suited for the growth of the bean, a plant with a weighty stem, and requiring a stiff soil to support it. They will yield large returns of the cultivated grasses and leguminous herbage-plants, though they are not so quickly covered with the natural herbage-plants of the soil, when laid down to perennial pasturage, as the lighter soils.

Clays, like the other soils, approach to their most perfect condition, as they advance to that state which has been termed loam. The effect of judicious tillage, and of the application of manures, is to improve the texture of such soils as well as to enrich them. Thus, clays in the neighbourhood of cities become dark in their colour and less cohesive in their texture, from the mixture of animal and vegetable matter, and thence acquire the properties of the most valued soils of their class.

Natural changes, however, yet more than art, have furnished the rich soils of clay. The best, for the most part, of the soils of clay, are those which are formed from the depositions of mud of rivers or the sea. The finest natural soils of this and other countries are those which are thus formed. The depositions of rivers, indeed, are not always of a clayey nature. In mountainous districts, they generally form soils of the lighter kinds. Where the sea, however, is the agent, or where both the rivers and the tides combine their action, the depositions generally are of the nature of clay. Such alluvial soils have everywhere local terms to mark their character and fertility. On the great rivers and estuaries in England, and in what are termed *carses* in Scotland, fine and extensive districts of this kind exist.

The next class of soils is the Light or Free. These are readily distinguished from the last by their smaller degree of cohesiveness. They are less suited for the production of wheat and beans than the clays, but they are better adapted to the production of

plants cultivated for their roots and tubers, such as the turnip and potato.

This class of soils may be divided into three varieties, differing from one another in certain characters, but agreeing in the common property of being less tenacious in their parts than the clays. The first of these varieties has been termed Sandy.

The sandy soils are of all the degrees from barrenness to fertility. When wholly without cohesion in their parts, they are altogether barren, and are only rendered productive by the admixture of other substances. The cultivated sands part readily with their moisture on the application of heat. They do not become hard like the clays, and, making no considerable resistance to external pressure, they are tilled with little labour.

The poorer sands are almost always marked by the scantiness of their natural herbage. This character they possess in common with the poorer gravels. Other soils, even the poorest, may be thickly covered with the plants peculiar to them; but the poorer sands and gravels usually put forth their natural herbs with a scantiness which denotes the absence of vegetable nourishment. Certain sands, whose powers of production do not accord with their external appearance, are termed *dead* or *sleepy* sands.

But sand, without losing its distinctive characters as a soil, may possess a greater cohesiveness in its particles, and be fertile by nature, or rendered so by art; and then the soils denominated sandy become of deserved estimation. Rich sands are early in maturing the cultivated plants, and hence they are familiarly termed *kindly* soils. They are fit for the production of every kind of herbage and grain. They yield to the richer clays in the power of producing wheat; but they surpass them in the production of rye and barley. They are well suited to the growth of the cultivated grasses, and, when left in perennial pasture, they are quickly covered with the natural plants of the soil; but their distinguishing character is their peculiar adaptation to the raising of the plants cultivated for their roots and tubers.

Another variety of the lighter soils, and allied in its characters to the sandy, is the Gravelly.

Sands will frequently be found to be the production of flat countries, gravels of the mountainous and rocky. The characteristic of the gravelly soils is the quantity of loose stones which they contain. These stones will be found to consist of those varieties of rock which the mountains of the country afford; and the nature of these rocks will frequently indicate the characters of the soil: thus soils, of which the stony matter is siliceous, are generally found to be barren, while those of which it is calcareous, are found to be fertile.

Sands, upon examination, will be found to consist of small particles of stony matter, and thus sands may be said to differ from gravels only in the more minute division of their parts. Yet, in this minuteness of division, there is generally sufficient to distinguish the two kinds of soils. The stony matter of the sand forms its principal component part, while the larger stones in the gravel, which give to it its name and character, seem only to be mixed with the other necessary parts of the soil. The stone of the one has undergone a considerable mechanical division, while much of that of the other has only been loosened, in sensible masses, from its native bed. Any light soil, mixed with a sufficient portion of stones, is gravel; and gravel, therefore, is merely the different kinds of light soils mixed with a greater or less proportion of stones.

Gravels, like sands, have all the gradations of quality, from fertility to barrenness. The loose soils of this nature, in which the undecomposed material is great, and the intervening soil siliceous, are held to be the worst of their kind. These are, in some places, termed *hungry* gravels, not only to denote their poverty, but their tendency to devour, as it were, manure without any corresponding nourishment to themselves. As the texture and quality of the intervening earth improve, so does the quality of the entire soil; and gravels, like sands and clays, advancing through all the intermediate degrees, may become of great fertility.

The rich gravels will produce all the cultivated kinds of grain. Their looser texture renders them less suited than the clays to the growth of wheat and beans, but they are admirably adapted to the

growth of barley and oats. They are quick in their powers of producing vegetation; and, from this quality, they are, in some places, termed *sharp* or quick soils. They readily admit of alternations of herbage and tillage, and improve in a state of perennial pasturage. They are generally trusty soils with regard to the quality of the grain which they yield ; and, in this respect, they differ from many of the sands, in which the quality of the grain produced does not always accord with its early promise. It is well, then, even in the best sands, to see a tendency to gravel, which denotes a sharpness, as it is termed, in the soil. Gravels, like sands, are suited to the culture of the different kinds of plants raised for their roots and tubers; and they are in so peculiar a degree adapted to the growth of turnips, that, in some parts, they receive the distinguishing appellation of *turnip* soils.

The other division of the lighter soils consist of those which are termed Peaty.

The matter of the soils of this class is dark in its colour, spongy in its texture, and full of the stems and other parts of plants, either entire or in a state of partial decay. It is generally tough and elastic; and, when dried, it loses much of its weight, and becomes inflammable. These, the most observable characteristics of the soils termed peaty, will distinguish them, in their natural state, from every other; and even when they shall have been greatly improved by culture, enough of their original characters will remain to make them known.

Peat, it has been said, consists of vegetable matter which has undergone a peculiar change. Under a degree of temperature not sufficiently great to decompose the plants that have sprung up upon the surface, these plants accumulate; and, aided by a certain degree of humidity, are converted into peat, which is either found in strata upon the surface of plains, or accumulated in great beds on the tops and acclivities of mountains, or in valleys, hollows, and ravines. Successive layers of plants being added to the mass, it continues to increase, under circumstances favourable to its production. Water is a necessary agent in its formation, and we may believe, too, a peculiar temperature, since it is only in the cold and tem-

perate, and not in the warmer, regions of the earth that true peat is found to be produced. The plants which form it have not entirely decayed, but still retain their fibrous texture; and, from the action of certain natural agents, have acquired properties altogether distinct from those which, in their former condition, they were possessed of. They have now formed a spongy elastic inflammable body, and so different from the common matter of vegetables, as to be highly antiseptic.

The plants whose progress towards decomposition has been thus arrested, are very various. Over the greater part of the surface of the primary and transition districts of colder countries, the peat is chiefly formed of heaths, mixed with the mosses and other cryptogamic plants which had grown along with them. Sometimes the peat has been formed in swamps and lakes, and at other times the humidity of the climate has been sufficient to form it into a continued bed, covering the whole surface of the country.

But vegetable matter which accumulates on the surface, undergoes various degrees of change; and hence peat differs in its properties according to the temperature and moisture of the climate. Sometimes the vegetable matter on the surface forms a stratum of dry turf, elastic and inflammable, but less truly peaty than that which is formed where there is abundance of water. Such is the peat formed on the siliceous sand and poorer chalks of some parts of England, and on the heathy sands of the north of Germany. Under other conditions of climate, again, the vegetable matter which accumulates on the surface proceeds through further degrees of decomposition, and forms a mass eminently suited to the growth of plants,—such is the vegetable soil formed in the woods of America by the falling of leaves. This substance, which improvident settlers exhaust of its nutrient principles by continued cropping, is wholly different from the true peat, which resists decomposition, and which covers so great a part of the surface of Scotland and Ireland.

Under the necessary conditions of temperature and moisture, any herbaceous and shrubby plants may be converted into peat;

but in the northern parts of Europe, it is chiefly the heaths, and especially that hardy species, *Calluna vulgaris*, or common ling, the decomposition of whose ligneous roots and stems produces peat. The grasses and softer herbaceous plants are usually entirely decomposed on the surface, or mingled with the matter of the soil,—forming what is termed *mould* by English gardeners and farmers, and by foreign writers, *humus*.

The soil formed of peat would, from its vegetable composition, seem to contain within it the necessary elements of fertility, and yet the excess of vegetable matter which it contains is injurious rather than useful. In the state of nature it is often found to be as barren as the sand of the desert, and scarcely to deserve the name of soil, until the labour of art has been extended to its improvement, and even then it is not entirely divested of its original characters.

The effect of a thorough draining off of the water of peat, continued for a long time, is to carry away the acid matter which it contains. When the water of peat has ceased to be turbid, and comes off clear, then we have the assurance that the peat is freed of the principles injurious to vegetation. This is the greatest improvement of which peat is susceptible, and when we have brought it to this condition, the main difficulty of improving it has ceased.

Peat may be brought by art to the state of what has been termed loam. In this ameliorated condition it becomes a soil of the lighter kind, well suited to the culture of the larger rooted plants. It is dark in its colour like the richest vegetable loam, and to the inexperienced eye may pass as such. But still, unless greatly corrected in its texture by the application of the earths, it is found to be porous and loose, too quickly saturated with moisture, and too easily freed from it. In this improved condition it will yield bulky crops of oats and barley, although the quantity of the grain will not always correspond with the weight of the stem, nor the quality of the grain with its quantity.

Peat is often found, in the natural state, largely mixed with clay, as in the Fens of England; but the soil, in this case, is not

one of true peat, but a mixture of peat and earthy matters. Such soils may, by cultivation, become of the highest fertility.

Soils, then, we have seen, may be distinguished according to their texture, when they may be divided into two classes,—the stiff or strong, denominated Clays,—and the light or free, subdivided into the Sandy, Gravelly, and Peaty; and all these, again, may be distinguished,

1*st*, According to their powers of production, when they are termed Rich or Poor; and,

2*d*, According to their habitual relation with respect to moisture, when they are termed Wet or Dry.

A like classification was adopted by the rustic writers of the Romans, who divided the ground, *terra*, into *spissa et rara, pinguis et macra, sicca et humida;* and this simple nomenclature is yet the best adapted of any that has been devised for the purposes of practice. The farmer regards soils chiefly with relation to their fertility, and the means of cultivating them, and he naturally classifies them according to these views: and any classification of soils, in which these considerations are disregarded, will prove to be of little value in the business of the farm.

A main distinction between soils, in practice, is founded upon their comparative productiveness. We constantly refer to soils with reference to their good or bad qualities, without adverting to the particular circumstances which render them of good or bad quality. We speak familiarly, for example, of land worth 30s., 40s., and 50s. per acre of yearly rent, without considering whether it be a fertile clay, a fertile sand, or a highly improved peat. But those other distinctions, which are derived from its constitution and texture, are essential, when we regard the manner of cultivating such a soil; for the same method of tillage, and the same succession of crops, as will be afterwards seen, do not apply to all rich or to all poor soils, but are determined by the character of the soil, as derived from its other properties.

Though soils are thus distinguished by certain characters, they pass into one another by such gradations, that it is often difficult to say to what class they belong. These intermediate soils, too,

constitute the most numerous class in all countries. The true peats, indeed, form a peculiar class, always marked by distinctive characters; but even these, when mixed with other substances, pass into the earthy soils, by imperceptible gradations. We may say, therefore, that the greater number of soils consist of an intermediate class, and that it is often difficult to bring them under any division derived from their external characters alone. Such soils, however, can always be distinguished by their powers of production. They are good, bad, or intermediate between good and bad; and their relative value is determined by the produce which, under similar circumstances, they will yield.

II. THE PROPERTIES OF SOILS, AS DETERMINED BY CHEMICAL ANALYSIS.

The determination of the nature and constitution of soils, by chemical analysis, falls within the province of chemistry, and not of agriculture, and is to be pursued rather as a branch of chemical and physiological inquiry than of husbandry. The chemist may draw useful conclusions from a careful analysis of the matter of the soil, and may, from time to time, be able to communicate results which may be serviceable to the practical farmer; but it is not necessary, for the ends of practice, that the farmer should be himself a chemist. The farmer cannot arrive at the science of mineral analysis without a knowledge of chemistry and the business of the laboratory, which he can rarely acquire, and which it is in no degree necessary to his success as a farmer that he should be possessed of. The remarks to be made on this subject will, therefore, be of a very general nature, and calculated merely to shew the connexion which exists between this branch of chemistry and the subject of soils.

The soil has been said to be a compound of mineral substances, mixed with a portion of matters derived from organic bodies, which may have been partly animal and partly vegetable.

The mineral matter of the soil forms by far the greater part

of it, and necessarily consists of the same substances which constitute the mountain-rocks and mineral masses which are found on the earth, and which form its crust or covering. The hardest rocks break down by degrees, and are decomposed by the influence of air and moisture. Sometimes the decomposed matter remains upon the rocky basis from which it had been derived, and there forms a soil; but often the action of water has mingled together the matter of different mineral masses and strata which are found on the surface.

The great body of the soil, then, is a mixture of the various mineral substances which are upon the earth, and is resolvable into the same constituent parts. Now, all the rocks and other mineral masses which exist on the surface of the earth, are resolvable into a few bodies, the principal of which are the four earths, silica, alumina, lime, and magnesia,—the oxides of iron,—and the alkalies, soda and potassa. In like manner, the great mass of the mineral part of the soil is resolvable into silica, alumina, lime, magnesia, the oxides of iron, soda, and potassa.

The manner in which this compound body may be conceived to exist is the following: Let it be supposed that the different minerals on the surface of the earth are more or less decomposed, broken, ground down, as it were, and mingled together.

Some are in the form of stones, and are therefore merely varieties of the different rocks of a country. These form loose stones and gravel, which we see accordingly to be everywhere mingled with the soil, and to form often a great proportion of it.

A more minute comminution reduces these mineral substances to sand. This is the form in which the largest part of all soils exists, and when it is in a very considerable proportion to the whole, the soil is termed Sandy.

When the parts are more comminuted still, and so changed by chemical or mechanical means as to be readily reducible to powder, the soil appears to be in the state favourable to vegetation. All our finest soils contain a large comparative proportion of their parts in such a state as that, when thrown into water, they are diffused through it in the form of a powder.

Of the substances which form the constituent parts of minerals, the most widely diffused is silica. Stones in which this earth exists in large quantity are usually very hard. The sand of the sea-shore is mostly siliceous, and siliceous sand forms vast deserts in every part of the world. Silica exists largely in felspar, which is one of the most abundant minerals in nature, and in quartz, which is a rock of constant occurrence, and of which the disintegrated parts have been everywhere washed into the plains to form an element of the soil. Silica is accordingly the most universally diffused mineral substance on the surface of the earth, and forms a part of every soil that is known to us. It exists in the soil, either in the state of sand, or in a state of chemical union with other substances.

It combines with alumina, forming fuller's earth and the true clays, and with lime, magnesia, potassa, and soda. It is itself nearly insoluble in water, but under certain conditions is taken up by this fluid, and so becomes fitted to enter the roots of plants, and be appropriated to their nourishment.

Alumina, next to silica, is the most generally diffused of the earths. In nature it always exists in a state of combination. United with silica, it forms a great proportion of all the rocks and mineral masses on the earth. It is, accordingly, everywhere found; and forms a part of every soil not wholly barren. It retains water more strongly than any of the other earths, and is the substance which chiefly communicates their plastic and ductile characters to the soils termed clayey.

Silica and alumina, then, forming the largest part of the rocks and minerals which exist upon the surface of the earth, enter the most largely into the composition of soils; and in these they are found to exist, either as grains of sand, or as gravel, or in a state capable of being easily reduced to powder.

Lime, the next of the earths mentioned, is one which is of wide extension, and performs an important function in the vegetable economy. Combined with carbonic acid, it constitutes the numerous varieties of marble, limestone, and chalk. In this and other combinations, it exists in rocks, in soils, in the waters of the ocean,

in plants, and in animals. It forms great beds, and numerous minerals in combination with silica and alumina.

Lime, existing in all the cultivated plants, must be supplied by the soil in the quantities required by the different species. It improves the quality of all soils, whether they are formed chiefly of clay, sand, or vegetable matter; and, when it is absent, the soil is deficient in an important constituent.

Silica, alumina, and lime, forming the principal part of soils, and, where any one of them prevails, giving its character to the soil, it is frequently convenient to distinguish soils, as being Siliceous, Argillaceous, or Calcareous. Where silica prevails, as in the case of many sands, we may call the soil Siliceous; where clay prevails, we may call the soil Argillaceous; and where lime exists in quantity, as in the case of chalk or marl, we may call the soil Calcareous.

Magnesia, in various states of combination, exists in nature in considerable quantity. It is found in combination with acids, such as the carbonic and sulphuric. It exists along with alumina, lime, iron, and other substances. The minerals of which magnesia forms a part, generally feel soft and unctuous; it is the principal constituent of various mountain-rocks; and thus being an element in many minerals, it must form a part of soils; and when it exists in such quantity as to give a character to the surface, we may term the soil Magnesian.

The next substance that exists largely diffused in the mineral kingdom, is iron.

Iron, as it is the most useful of the metals, so it is that which is the most generally diffused. It is derived, for the uses of the arts, from a series of minerals termed ores of iron. It is found extensively in mountain-rocks; and it exists, accordingly, in more or less quantity, in almost every soil. It is found either in the state of protoxide, the black, or the red oxide. The protoxide is usually in combination with acids, and is readily converted into the red oxide, by the action of the air and other agents. Soils which contain much iron may be termed Ferruginous.

Manganese, a metal allied in its characters to iron, is likewise found in the soil: but it is greatly more rare in nature than iron, and probably serves a less important function in the economy of vegetation.

The alkalies, potassa and soda, are extensive products of the mineral kingdom, and exist in various states of combination in the soil. They are found chiefly in the state of carbonates and sulphates, and exercise an important influence on the fertility of soils and the growth of plants.

Besides silica, alumina, lime, magnesia, the oxides of iron and manganese, potassa and soda, soils contain common salt and other chlorides, carbon, sulphur, and phosphorus.

Soils further contain a portion of matter derived from organic bodies in certain states of mixture and combination. This portion rarely, except in the case of peaty soils, or of rich moulds surcharged with vegetable matter, amounts to 8 or 10 per cent. of the whole weight of the dried soil, and sometimes does not exceed 1 or 2 per cent. It is termed *humus* by modern writers; but the term *humus* conveys no definite idea, since, under this name are comprehended substances entirely distinct as chemical compounds. This humus, so called, tends to form compounds, which combine with the alumina, the lime, and other mineral bases in the soil. The compounds thus formed are sometimes soluble in water; and sometimes they are insoluble, but susceptible of decomposition and change, by the air and other agents. Thus, then, by means of the earthy bases of the soil, the organic matters which it contains are preserved, or rendered fitted for the uses of plants.

Plants themselves consist essentially of carbon, oxygen, hydrogen, and, in smaller quantity, of nitrogen, or azote; and the greater part of their substance consists of carbon in combination with the elements of water. Now, water is derived from the soil, to which it is conveyed by rains, dews, and springs, and is received by the porous extremities of the roots of plants, whence it is carried, as sap, to the leaves and other organs. The carbon is partly

derived from the soil, and partly from the air of the atmosphere, where it exists in combination with oxygen, in the state of carbonic acid gas.

The leaves possess the property of absorbing this gas, which is then decomposed in the plant. The oxygen is mostly restored to the atmosphere, while the carbon remains. Thus the carbon, of which the bulk of plants consists, is derived partly from the soil, and partly from the air, as soon as the leaves, with their myriads of absorbing pores, have been developed and expanded. It has been calculated, although on uncertain data, that one-half or more of the carbon of the plants is derived from the atmosphere. But, however this be, we are entitled, under any reasonable hypothesis, to infer, that carbon is supplied to plants from both sources, although in various degrees in different plants, and at different periods of their growth.

With respect to the nitrogen which enters into the composition of plants, this substance, though in smaller quantity, must be supposed to be no less necessary to the perfecting of the vegetable organism than carbon and the elements of water. It may be derived in part from the atmosphere, four-fifths of whose volume consist of nitrogen; but it is chiefly derived from the decay of organic matters in the soil.

The other substances which enter into the composition of plants, namely, silica, alumina, lime, magnesia, the oxides of iron and manganese, soda and potassa, common salt and other chlorides, sulphur and phosphorus, can only be derived from the soil, or from the water which is conveyed to the soil.

Now, the soil being a reservoir, as it were, for containing the mineral substances which plants consume in growing, it must contain these substances in such quantity, and in such states, as shall afford the matter which the living plants require for their due development. Sometimes one or other of the elements required may be wanting, or in deficient quantity, or in a form incapable of acting on plants, and then the soil will be, in a greater or less degree, defective. On examining soils by the methods of chemical ana-

lysis, we find them to consist of all, or nearly all, the following substances :

1. Silica, either in a state of sand, or in combination with earthy and alkaline bases. In these different states silica forms the greater part of all soils, amounting often to more than 90 per cent. of the entire mass.

2. Alumina, in combination with silica and other matters in the soil. Alumina is an important constituent in every soil, and, in proportion to its quantity, gives tenacity and cohesion to the mass.

3. Lime, in combination with carbonic, sulphuric, and other acids, existing sometimes in minute quantity, and sometimes forming a large proportion of the weight of the soil.

4. Magnesia, existing like lime in combination with carbonic and other acids.

5. Iron, either in the state of protoxide, when it is usually combined with sulphuric acid, forming copperas ; or of peroxide, in which state it mixes with the matter of the soil, and communicates to it a red colour. When the protoxide, whether free or in combination, is exposed to the action of the air, it tends to become peroxide.

6. Manganese, usually in the state of peroxide, and for the most part existing in minute quantity.

7. Potassa, in combination with carbonic and other acids, and forming saline compounds, soluble in water.

8. Soda, existing in the like combinations, and sometimes supplying by its presence the absence of potassa.

9. Chlorine, in combination with sodium, forming common salt, or with potassium, forming chloride of potassium, or with the base of lime, forming chloride of calcium, and sometimes with hydrogen, forming chlorohydric or muriatic acid.

10. Carbon, as charcoal, or as a carburet ; or in the state of carbonic acid, in combination with earthy and alkaline bases.

11. Sulphur, sometimes in the state of sulphuret, but usually in the state of sulphuric acid, which enters into combination with

lime or magnesia, or with the alkalies, or with alumina, and sometimes with protoxide of iron.

12. Phosphorus, in the state of phosphoric acid, generally combined with lime or magnesia, and sometimes with oxide of iron.

13. Matter derived from organic bodies, in part soluble and in part insoluble in alkaline solutions, and yielding nitrogen and its compounds, carbon and its compounds, &c.

14. Water, either chemically combined, or free, and holding in solution carbonic acid and other substances.

Such is the very compound constitution of the soil, which may be regarded,—

1. As an instrument for fixing the roots of plants.

2. As a magazine for containing the various substances which plants in growing require.

3. As a menstruum, in which the various chemical changes are performed, by which different substances are fitted to afford nourishment to the organs of plants.

The medium for dissolving and conveying the soluble matter of the earth to the growing plants is water, which the soil is able to absorb in large quantity.

The air may be considered as a vehicle for conveying water to the soil. It is continually charged with aqueous vapour, which partly descends to the earth in rains, and is partly deposited in dews in the cool of the night. In many countries it never rains at certain seasons, and the whole moisture is supplied by the dew. In this case in an especial degree, and in all cases in a certain degree, the power of the earth to absorb moisture from the air may be regarded as connected with the means of the soil to nourish plants.

All our fertile soils, accordingly, have a power of thus supplying themselves with moisture, and of retaining it for the proper time; while infertile soils either have less of this absorbent power, or retain the fluid absorbed for a shorter time. This was known to the ancients, one of the marks which they gave of a fertile soil being, that it freely imbibed water.

Of the different matters which enter into the composition of soils,

animal and vegetable substances possess the greatest power of absorbing moisture; and the addition of animal and vegetable substances always increases the absorbent powers of soils.

Of the pure earths, the least absorbent is silica, and it is that also which parts the most readily with its moisture. A soil, consisting of too great a proportion of siliceous sand, imbibes the aqueous vapour of the atmosphere with slowness, and parts with it quickly. A soil of siliceous sand will scarcely be penetrated by the dews of night, and will part with its water on the first action of the morning rays of the sun.

While pure silica will imbibe scarcely a fourth part of its weight of water, lime will absorb nearly its own weight, and alumina two and a half times its weight. But while the silica will absorb a smaller quantity than alumina or carbonate of lime, it will allow it to evaporate twice as quickly as carbonate of lime equally divided, and five times more quickly than alumina in the same state. The addition of carbonate of lime or alumina to a soil containing too much silica, never fails to increase its powers of absorption.

But, although certain earths in their separate state have greater power of absorption than others, it does not follow that a soil consisting chiefly of that one earth would possess a greater power of absorption than a soil composed of a mixture of earths, even though these earths should in themselves be less absorbent. Thus a soil, consisting chiefly of clay, though alumina is itself the most absorbent of all the earths, taking water up in the greatest quantity when poured upon it, as well as retaining it the longest, is not really so absorbent of moisture from the air as when it is mixed with sand. Hence, the stiffer clays are not the soils which absorb water very readily from the atmosphere. Such soils, when the weather is dry, become indurated upon the surface, which presents an obstacle to absorption; and thus we find, that the vegetation of very stiff clays is almost as soon injured by drought as that of sandy soils, and much more quickly than that of good loams.

A mixture of siliceous sand, then, with a very aluminous soil, although the sand is the less absorbent substance of the two, increases the general powers of absorption from the atmosphere;

so also does a mixture of lime, and, in an eminent degree, of animal and vegetable matter.

Sir Humphrey Davy compared together the absorbent power of various soils with respect to the moisture of the atmosphere, and found it to be the greatest in the most fertile. Thus 1000 parts of a very fertile soil from the banks of the river Parret in Somersetshire, when dried at 212°, gained in an hour, when exposed to air saturated with moisture at the temperature of 62°, 16 grains.

1000 parts of a soil from Mersea in Essex, worth 45s. an acre, gained, under the same circumstances, 13 grains.

1000 parts of a fine sand from Essex, worth 28s. an acre, gained 11 grains.

1000 parts of a coarse sand, worth 15s. an acre, gained only 8 grains.

1000 parts of the soil of Bagshot Heath gained only 3 grains.

We cannot infer, however, that the fertility of soils can be measured by their power either to absorb or to retain moisture, for this is not the only condition of fertility in soils. But it may be inferred, that all productive soils have a considerable power of absorbing moisture, and retaining it when absorbed, and that this property does not depend on the prevalence of any one substance, but on a mixture of several substances.

Soils, in absorbing aqueous vapour from the atmosphere, absorb carbonic acid, and it may be believed the matter of those putrid exhalations which the earth gives off, and charged with which the vapour of the air descends at night in dews, to enrich the earth and refresh the growing plants. The air of the atmosphere likewise acts through the medium of its oxygen in decomposing inert vegetable matter; and hence the benefits which are seen to result from exposing the soil to the action of the atmosphere, or from loosening its parts by tillage, so as to admit the air into its pores.

The fertility of soils depends in part on their physical properties, and in part on their chemical constitution. With respect to their physical properties, soils should never be so loose or porous as that they shall be moved by the winds, nor so stiff and argillaceous as that they cannot be freed from an excess of water, or

tilled without extreme labour. With respect to their chemical constitution, they should contain in due quantity the elements which are required by plants for their growth and full development, namely, the earthy and alkaline bases, with the silica, the carbon, the phosphorus, and other substances which enter into the vegetable organism. It does not appear that any precise proportion of the different component parts is requisite in order to constitute a fertile soil; for soils may be infinitely varied in the proportion of their ingredients, and yet be equally fertile. The essential condition seems to be, that the substances which the plants consume in growing shall be present in the due quantity, and in the proper states of combination. Hence we see the beneficial effects of a mixture of many substances in the soil, and the little fertility of soils containing a small number of elements, such as chalk: and hence also the less fertility of the soils of mountains compared with those of the valleys, where the action of water has mingled together the debris of different mineral strata.

From the enumeration before given of the matters which enter into the composition of soils, the soil will be seen to be one of the most compound substances in nature, being, in truth, a receptacle for the various matters found on the surface of the earth. Its exact composition can only, in any case, be determined by rigid chemical analysis, which the farmer can rarely make himself, and which, when communicated to him, he can rarely use. But the farmer is able to determine the nature of its soil by its texture, its depth, its productiveness of plants, and other sensible properties; and happily the knowledge so obtained is sufficient for all the ends of useful practice.

A knowledge of the intimate chemical constitution of the soil is highly worthy of being obtained, and the subject would deserve to be pursued by men of science, were there no other aim or result than the resolving of chemical and physiological questions. But too much must not be looked for from such inquiries, as teaching the farmer new methods of practice. The farmer knows, for the most part, better than the chemist, when a soil is good or bad, when it is improvable by ordinary means, and when it is too bar-

ren to repay the expenses of culture; and he knows better than the chemist how to keep it clean, dry, and as productive as the means at his command will allow, with a due reference to the return as compared with the expenditure. But this latter knowledge is not derived from the laboratory, but the fields, and is a branch of a practical business, in which chemistry can render little aid. Whatever results chemical analyses of the soil may hereafter conduct us to, it must be admitted that, as yet, they have been interesting to the scientific inquirer, rather than useful to the farmer. Every garden and well-cultivated field shews that the soil may be brought to its maximum of fertility without dependence on any conclusions yet arrived at by the physiologist and the chemist. Perhaps not more than a few dozens of chemical analyses of soils have yet been made in Europe, sufficiently exact to aid the purposes of science, while the great mass of those which are made and communicated to farmers as something necessary or useful to them, are equally worthless for science and practice.

III. THE PROPERTIES OF SOILS, AS DETERMINED BY THEIR GEOLOGICAL RELATIONS.

When we examine the solid matter of this earth to the utmost depths to which we have yet penetrated, two classes of mineral masses present themselves. The one consists of beds or strata, lying one upon the other in a certain order, like matter deposited from a fluid in which it had been diffused; the other consists of indurated masses, which do not present the like traces of deposition. The first, or stratified masses, are either hard and compact, like slate, limestone, and sandstone, or soft and merely coherent, like the sands and clays on the surface. The second, or unstratified masses, are always more or less hard, and generally crystalline. They are sometimes termed Volcanic rocks, as indicating their analogy with the melted matter of volcanoes; or Igneous, as indicating the action of heat. Although they may be reasonably supposed to have been a deposition from a fluid medium, yet, having

been forced up again, in a state of fusion or semifusion, from the depths beneath, they have generally lost the traces of stratification. They often, however, present themselves in layers, like successive floods of lava poured over one another, and often they assume regular figures, the result of a grand process of cooling. They are frequently interjected between the beds of the stratified deposites, and sometimes they fill crevices and fissures, forming veins and dykes. Sometimes they spread over the surface of the stratified beds, or, rising high above them, form lofty mountains and mountain-chains: sometimes they penetrate through the masses of pre-existing mountains, whether stratified or unstratified, and overtop and cap their summits as with a mantle: and often, without having reached the surface, they have heaved up the beds above them into knolls and mountains, and broken or displaced their strata.

The stratified masses, it has been said, are either hard and compact, or soft and merely coherent. Below them all, and consequently, the first in the order of deposition, is Granite, beneath the mass of which no human power has penetrated. It may be termed the basis upon which all the other earthy and rocky matters of the crust of the earth, and all the waters of the ocean, rest. But while it lies beneath all the other deposites, it often rises high above them all, forming lofty mountains and mountain-chains; and often, forced upwards by subterraneous action, it has burst through the stratified masses above it, rupturing or overturning them. In the latter case, it may be classed with the rocks termed Igneous.

Immediately above the fundamental granite, is a series of deposites of prodigious thickness, partaking of the same mineral characters as the granite, and laid in beds more or less perfectly defined. They rest upon the disturbed and broken surface of the granite, and, like it, have been subjected to great changes by subterraneous forces. They are all eminently hard and crystalline. They are sometimes termed Crystalline Schists, and sometimes Metamorphic Rocks, as indicating that they have been changed by the action of heat. Within the masses of these ancient rocks, no

trace of animal existence has yet been found. Not a shell exists to prove that, during their deposition, animal life had been called into existence upon this planet, and we do not know whether this earth had then become the habitation of animated creatures. Whether vegetable matter was produced on these masses after their deposition is unknown, but the occurrence of a species of coal amongst the crystalline schists renders it probable, that in this primeval era plants had been produced, and that thus the simplest condition of life had begun. The principal members of this vast group are gneiss, slates, quartz, limestone, and serpentine.

The crystalline schists with the underlying granite were, by the earlier geologists, termed Primary, a term perfectly suitable, and which merely indicates that, lying below the other known rock-formations, they are the primary or older, just as the first-laid layers of stones in a building are the lowest, and may be termed the oldest.

The Grampians, and other mountains of the North of Scotland, forming about two-thirds of the surface of that country, consist of granite and the crystalline schists. The same series is found in Ireland, constituting the greater part of the county of Donegal, and a part of Londonderry and Tyrone, in the north-west, and a great part of Galway and Mayo, in the west. Members of the same system are found in the east of Ireland, in the south-west of England in Devonshire and Cornwall, in the Isle of Anglesea, and in the beautiful little islands pertaining to the British Crown, on the coast of Normandy.

The rocks of the primary series are formed of various minerals, which differ in their composition; and differences accordingly exist in the soils produced by the several members of the series, when they waste and crumble down. But all these soils resolve themselves into silica, alumina, lime, the alkalies, and other mineral constituents of soils. Sometimes the soils produced by the disintegration of these rocks are fertile, as in the islands before referred to on the coast of Normandy. Even in the more mountainous tracts of Scotland and Ireland, there are found, in the dells and vales into which the finer particles have been carried from the higher grounds, perfectly productive soils. But, for the most

part, the primary districts of this country, from the altitude and steepness of the mountains, and the slow decomposition of their rocky basis, are covered with a scanty natural vegetation, and, therefore, are unproductive. They are widely covered with heaths and great beds of peat; they produce noble forests of pine; but, for the most part, they are devoted to pasturage, and left in their natural state of wildness. Where they admit of cultivation, the great means of improvement of which they are susceptible are draining and the application of calcareous matter.

Hard and indestructible as the substance of these crystalline rocks appears, they are yet formed to yield to the influence of external agents and chemical changes. They crumble down, and their disintegrated parts are washed away. It is an opinion confirmed by many analogies, that, in the lapse of unknown periods of time, the disintegrated parts of great mineral masses have been carried into the ocean, where they have formed new deposites, which have again been rendered dry by changes in the relative levels of the lands and seas. Thus, entire continents have been swept away and buried in the ocean, by changes similar in kind to those which we yet see in progress on every rocky coast, and raised again, in whole or in part, from the waters in which they had been submerged during epochs of unknown duration. The successive elevation of new land from the depths of the ocean, is proved by all the evidence which the state of the crust of the earth can supply. It is nothing that the imagination is startled by the vastness of the periods of time required for such mighty changes. Millions of ages may be of little account in the absolute duration of suns and worlds.

The series of deposites, the next in order above the primary, were, by earlier geologists, termed Transition, as resembling, in certain characters, the primary, and forming, as it were, a passage from the older to the newer systems. Like the primary deposites, they have been raised into hills and mountain-chains; but their strata have been usually less elevated, broken, and contorted, and they are likewise less hard and crystalline. They have been deposited in succession during vast and unknown epochs of time, and elevated by successive actions. The upper series contain fossil remains

of marine animals, so that animal life had been called into existence during the period of their deposition; but not one of the species found in them is identical with any now found existing in the land and seas of the globe. These vast deposites generally constitute tracts of mountains, which are, for the most part, less wild and rugged than those of the primary countries. In these islands, they constitute the range of hills stretching from St Abb's Head westward to the Irish Channel, forming the Lammermuir Hills, and the high lands of the counties of Roxburgh, Peebles, Selkirk, Kirkcudbright, and Dumfries. Farther to the north, they form a part of the county of Banff, and stretch across the island in a narrow belt. They constitute a great part of the counties of Westmoreland and Cumberland, and stretch through the Isle of Man. They form the mountains of Wales, the greater part of Cornwall, and a portion of North and South Devon. They extend along the whole of the south of Ireland, appear in the central high lands of Tipperary, and cover a large proportion of the counties of Down and others in the province of Ulster.

The rocks of these mountains being less indurated and crystalline than those of the primary group, they generally crumble down more readily under the influence of air and water, and produce a thicker bed of loose earth on the surface. One of the principal members of the series is greywacké, alternating with which are other beds or layers,—argillaceous, siliceous, and calcareous. When the argillaceous beds come to the surface, the soils produced are frequently a cold clay or till, only to be thoroughly improved by draining and liming: the siliceous beds often produce barren heaths; but when the debris of the calcareous layers come to the surface, or are found in the lower valleys into which the abraded particles from the higher grounds have been carried, the soil may arrive at considerable fertility. The principal vegetable productions of the mountains are heaths, rushes, sedges, and the coarser herbage-grasses, and they are largely overspread with peaty turf and deep bogs. The lower grounds are partially cultivated in Scotland and Wales, and largely in Ireland.

The primary rocks may be termed primeval, for we have no

knowledge of any anterior condition of the surface of the globe. They may be supposed to have been deposited, by means of a grand series of chemical changes, from a fluid which surrounded the earth, but concerning which we cannot reason securely, because nothing similar has come under the cognizance of our senses. Yet if the earth were originally a heated mass, we must believe that the water which surrounded it was intensely heated, and partly in the state of vapour, and that as the surface of the earth cooled, the waters would diminish in volume, "the waters under the heaven be gathered together," and "the dry land appear." By whatever grand system of laws these natural changes have been ordained, we know, by all the evidence which the case allows, that the crystalline schists were deposited from a fluid medium; and with respect to the granite associated with them, it consists of the same materials; for granite passes by insensible degrees into the sedimentary deposites, and often cannot be distinguished from them. The transition rocks seem to have been in part deposited by the same actions as the primary, because many of them cannot be distinguished from the primary; and in part by a mechanical deposition of the detritus of the preceding primary formations.

Above the transition system rests an immense series of deposites, usually comprehended under the general term Secondary. It appears that they have all been deposited in the bed of an ocean, and, in a few cases, of lakes afterwards submerged by the ocean. They are all in beds, which are more or less flat, except where they have been disturbed by subterranean forces; and they are usually inclined to the surface, as if they had been deposited on the shelving shores of an ocean, or uplifted by a force acting from

Fig. 1.

beneath. Further, there exist the proofs of an alternate rise and

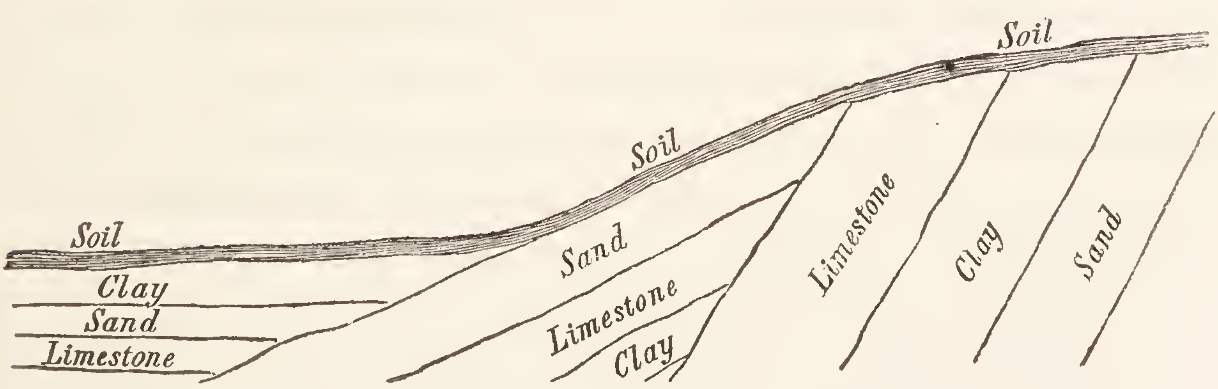
fall, so that the same tracts have been more than once submerged, and more than once raised up again. The periods of time in which these vast changes have taken place, are wholly unknown. But we know that, during their occurrence, whole species and tribes of animals had been called into being, and again ceased to exist; so that we are to estimate the periods of these amazing mutations not by ages, or the lives of individuals, but by the endurance of species, genera, and tribes. Of all the species that have lived and perished during this immense period, not one can be identified with any now existing upon the globe.

The Secondary formations may be arranged in the following order :—

1. The Old Red Sandstone.
2. The Carboniferous System, or Coal Formation.
3. The New Red Sandstone, or Saliferous System.
4. The Lias and Oolite.
5. The Chalk.

These formations consist each of alternate beds of sand, clay, limestone, and other substances. The manner in which the inclination of the strata causes the different members to reach the surface, and form tracts of greater or smaller extent, may be represented in a diagram, thus—

Fig. 2.



1. The Old Red Sandstone is found in hills of some elevation, or resting upon, and surrounding, the flanks of the transition hills, and extending into the plains. One part of the series frequently consists of coarse siliceous conglomerates, forming hungry gravels; another of incoherent sands, producing barren soils; another of

very indurated sandstones, which, decomposing slowly, and resisting the percolation of water, tend to produce tracts of peat; and another consists of limestone and marly beds, which form rich and mellow soils. In England, the latter members of the series constitute the beautiful tract of rich country which lies between the vale of Severn and the mountains of Wales, comprehending the whole of the county of Hereford, and parts of the shires of Monmouth and Brecknock; but when the arenaceous beds come to the surface, even in the midst of these richer tracts, the soil changes. In Scotland, large tracts of the old red sandstone are so barren as to bear only heaths, mosses, and lichens; while admirable soils are found in the same country in the same formation, as on the Moray Frith, in the district of Strathmore, in the valleys of Tweed and Tay, and in the tract of land which stretches from the base of the Lammermuir hills by Dunbar along the noble estuary of the Forth.

2. Resting upon the old red sandstone, and therefore the more recent deposition, is the grand Carboniferous group, or Coal formation, deposited when a rich vegetation existed, and when the temperature of the globe must have greatly exceeded that which it now possesses,—for amongst the vegetable remains of this period, even in the higher latitudes, are pines like those which grow in the warmest regions, arborescent ferns, gigantic equisetaceæ, and palms.

In England, the lowest member of this series is the Mountain Limestone, in which the first traces appear of those vast ligneous deposites which form coal. It occupies a portion of the chain of heathy hills and bleak moors which stretches from Derbyshire northward into Northumberland, and which separates the waters which flow westward to the Irish sea from those which flow eastward to the German Ocean. In Scotland, the mountain-limestone alternates with beds of coal; and in Ireland, it occupies a great part of the surface of the country. The dark-blue limestone which, in England, forms the principal member of the series, decomposes slowly, and only yields a soil of moderate fertility in the lower grounds and valleys. In Scotland, the mountain-limestone de-

composes readily, and forms good soils; and in Ireland it produces tracts of fertile country.

Immediately above the mountain-limestone there exists in England a series of coarse sandstones, alternating in some cases with shales and siliceous limestones, termed the Millstone Grit. The millstone grit partially surrounds some of the coal-fields. The soils formed from it are, for the most part, cold and ungrateful, unless in the valleys, or when mixed wth transported debris.

Next to the Millstone Grit, in the ascending series, are the true Coal Measures, consisting of alternating beds of siliceous sandstones, slaty clays, limestone, ironstone, and coal. These deposites are contained in great irregular basins, termed coal-fields, where the plants which formed the coal may be supposed to have been produced, and into which vegetable matter may have been swept from the adjoining lands. The largest and most northerly of these basins, stretching across the island, encloses the entire estuaries and valleys of the Forth and Clyde: the next abuts on the Bristol Channel, occupying nearly the whole of Glamorganshire, and a part of the shires of Monmouth and Pembroke:—the most westerly is on the river Shannon towards its mouth, spreading over a great part of the counties of Limerick, Clare, and Kerry. Of the other great coal-fields, one is that of the Tyne, stretching over the greater part of the counties of Northumberland and Durham; and two are found in the central counties, one on the east, and one on the west, of the limestone hills of Derbyshire. From these and some other fields of coal, Great Britain draws those amazing supplies of this mineral, which, for so long a time, have rendered her one of the most rich and powerful of countries.

The soils directly derived from the shales, the sandstones, and other rocks of the coal-formation, are often coarse, ungrateful, and ferruginous, except in the lower grounds, to which the finer particles have been carried from the higher. But the lower parts of the coal-fields are frequently thickly covered with transported materials, which overspread the debris of the ancient deposites. While the higher lands, therefore, of the coal-formation may exhibit the coarse ferruginous soil referred to, the lower grounds, as in the

vales of the Lothians, the Tyne, and the Shannon, may be of the highest fertility.

3. The New Red Sandstone is the next in order above the carboniferous system. The lowest member of it in England is a formation of limited extent, termed the Magnesian Limestone, the principal member of which contains much carbonate of magnesia, giving to the limestone a yellow colour. It extends in a narrow belt, from near South Shields by Sunderland, Darlington, Ripon, Knaresborough, and Ferrybridge, to Nottingham. It yields a light soil, only moderately fertile in the natural state, yet improvable, and well fitted for the growth of barley and turnips. In the valleys of the rivers which intersect it, as of the Tees, the Ure, the Wharf, and the Air, fine tracts of loam present themselves.

Above the magnesian limestone the New Red Sandstone consists of alternate beds of marls and marly clays, with intervening layers of sand. It forms continuous plains, swelling into gentle eminences, but scarcely rising into hills. It commences on the Nith, about twenty miles north of Dumfries, and, extending across the Solway, forms the rich vale of the Eden. It is interrupted by the mountains of Westmoreland, reappears in Lancashire, stretches across the Mersey, and occupies the county of Cheshire, and a part of Shropshire and Staffordshire. It stretches, by the vale of Severn, through Worcestershire, appears partially in Somersetshire, and expands into the fine valleys of Taunton, Exeter, and Honiton, in the county of Devon. From the mouth of the Severn it extends northward, through part of the shires of Warwick, Leicester, and Derby, and follows the course of Trent to the Humber. It then forms the rich vale of York, and terminates in the lower valley of the Tees.

The surface of this formation, when derived from the marls and marly clays, forms a deep red-coloured soil, varying from light loam to a stiff, and rarely stubborn, clay; but when the arenaceous beds prevail, tracts exist of infertile land bearing heaths and furze. In certain parts, too, are drifted materials of rolled pebbles, and tracts of peat, as at Chat Moss and on the Solway Frith. But the new red sandstone, following the course of many fine rivers,

as the Severn, the Exe, the Trent, the Ouse, the Tees, forms the most extended tract of fine champaign country in England.

4. The Lias and Oolite are the next in order of deposition above the new red sandstone. They are distinguished from the formations that precede them, by their being essentially calcareous in their principal members. They form a transition, as it were, from the previous formations, to the chalk, which consists essentially of carbonate of lime. Dividing the new red sandstone from the districts of the chalk, they commence with the well-known cliffs on the Yorkshire coast, near Whitby, where they expand into the eastern moorlands of Yorkshire. They then become a narrow ridge, separating the vale of York on the west, from the chalky wolds of the same county on the east. They cross the Humber, following the course of the vale of Trent to the eastward, and pass through parts of the counties of Lincoln, Leicester, Rutland, Warwick, Northampton, Oxford, and Gloucester, separating in all cases the new red sandstone on the west, from the countries of the chalk on the east. They then pass through Somersetshire and Dorsetshire to the English Channel, terminating in a line of cliffs remarkable for the beauty and variety of their fossil remains.

The lowest member of this extensive series is the Lias, which consists of a deposition of thick beds of blue clay, with strata of limestone, generally blue. It stretches diagonally across the island in a long irregular belt, from Whitby to Lyme Regis on the western confines of Dorsetshire. The soil presents every gradation of quality, from a cold stubborn clay to a rich clayey loam. It is, for the most part, in old pastures. Within it are included some of the finer dairy districts of the counties of Leicester, Warwick, Gloucester, and Somerset.

Immediately above the lias is the Oolite or Jura limestone, mostly forming a kind of table land, which stretches in the same direction as the lias, from the eastern moorlands of Yorkshire to the Isle of Portland in the Channel. It is the formation of epochs of immense duration, and is conveniently divided by geologists into three groups—the lower, the middle, and the upper. It consists of alternating beds of limestone, clay, marl, and sand. It is exceed-

ingly varied with respect to the quality of its soil, or as one or other of its members prevails, or as the soil is in the higher or lower grounds. Much of it is a thin brown-coloured sand, technically termed a dead or sleepy sand, and some of it is a deep marly loam. Part is uncultivated and in sheep-walks, but the greater portion is enclosed, and in a state of cultivation or old pasture. One of its members, the Oxford clay, stretches from the west of Dorsetshire, north-east by the city of Oxford, through the shires of Buckingham, Bedford, and Huntingdon, until it passes underneath those large tracts of fens which are found in the counties of Lincoln, and others. The Oxford clay is in some cases a stiff cold soil; in other cases, a deep clay, stubborn and difficult to till; but, when freed from water, eminently productive of wheat, beans, and clover.

These extensive deposites contain amazing remains of animals now extinct, amongst which are flying lizards, huge tortoises, crocodiles, and other stupendous reptiles. One of these, destined, as his conformation shews, to live in water, was from 20 to 30 feet in length, with the head of a lizard, large eyes, and formidable teeth. His feet were fashioned like vast paddles, enabling him to swim on the surface of water. Another was essentially distinct from any known animal form. He had long paddle-shaped feet, and a neck of enormous length.

5. The last of the grand series of secondary formations is the Chalk; but there is a partial and very remarkable deposite in England, whose position shews it to have been anterior to the chalk, namely, the Wealden.

The Wealden differs from all the other secondary formations enumerated, in being a deposite from fresh water, apparently the mouth of some vast river, derived from continents that have now disappeared, and forming a delta like those of the Ganges, the Amazon, and other greatest rivers. This delta is not confined to England, but appears in France, so that it must have covered in all a space of upwards of 40,000 square miles. The portion of it which is in England is partly in Kent, and partly in Surrey and Sussex. The lower member is termed the Iron or Hastings sand,

which extends westward from Hastings to the river Arun, with a medium breadth of ten or twelve miles. The iron sand forms a light brownish soil, mostly ferruginous, and naturally infertile, yet capable, under proper cultivation, of producing good crops of barley and turnips. The clay of the wealdens is surrounded by this arenaceous tract. It produces a pale and exceedingly stiff unctuous soil, hardening like brick when dried, and obstinately retaining water. It was anciently covered with a dense forest, and still produces noble oaks, from which it has sometimes been called the Oaktree Clay.

The wealden is not less remarkable than the formations which precede it for its fossil remains. In it have been found pines and arborescent ferns, whose types now only appear in the hottest regions, and huge reptiles which had been buried in the mud of the delta. Amongst these is one whose teeth shew it to have fed on plants, and whose bones lead to the computation, that individuals must have reached the dimensions of the largest whales. We are struck with wonder, not only at the existence of animal forms so different from those which are now found on the earth, but at the vastness of time required for changes, during which, not only species, but tribes and families, had been called into being and extinguished.

Posterior, then, in the order of time, to the deposition of the wealden, is the great Cretaceous system, or Chalk. The chalk occupies a large space in the east and south-east of England. It commences at Flamborough-head on the north, forming the wolds of Yorkshire, and stretches southward through the counties of Norfolk, Suffolk, Hertford, Buckingham, Oxford, Berks, Wilts, and Dorset, to the British Channel. It occupies the greater part of the county of Hants, from which it stretches eastward, embracing the wealden, to the English Channel and the Downs. Traces only of some of its members extend to Scotland. In Ireland it is found covered by the basaltic tract of the north-east of that island.

The chalk of England consists of several members, the lowermost of which are two beds of sand, with an intervening one of clay. The sand is distinguished by its green particles. The Green Sand

forms a belt, usually narrow, but in some cases several miles in breadth, skirting the outer edges of the chalk. It generally forms a light, friable, kindly soil. In other cases it is of little fertility, and produces heaths and furze. The clayey bed, termed Gault, forms, for the most part, a stiff, adhesive, marly soil. In certain parts, as in Huntingdon and Cambridge, it is a cold, intractable clay; in other cases, however, where mixed with the green sand and chalk, it forms an excellent clayey loam.

The true chalk consists essentially of carbonate of lime, in the lower beds aluminous and marly, and in the upper more free from aluminous matter, and largely mixed with flints. The flinty chalk of the upper beds is naturally very steril, and the tract which it occupies is for the most part unenclosed, forming wide downs for the pasturage of sheep. The lower beds, from being mixed with clay and sand, are greatly more productive, and are frequently employed to be mixed with the flinty chalk, in order to fertilize it. It is, in truth, only when clay or sand is largely mixed with chalk, that it becomes in any way productive as a soil. In the plains and valleys, where siliceous and aluminous matter covers the surface, and is largely mixed with it, the chalk becomes a soil of great fertility; but in most of these cases, the true chalk may be said to form the subsoil rather than the soil. No general description will apply to the countries of the chalk with respect to their productiveness, since they present every variety of quality and texture in the soil, from that of the bare wolds and arid downs, to that of the warm valleys and cultivated plains. One common character, however, applies to the countries of the chalk, namely, their extreme dryness. Water readily finds its way downwards, and is accordingly often so scarce, that it must be derived from deep wells, or else collected in ponds.

The chalk formation is of prodigious extent in Europe, stretching from England all eastward to beyond the Caspian Sea, and being found almost from the base of the Scandinavian Alps to the Pyrenees. During the countless ages in which it was in the course of deposition, an ocean must have spread through central Europe into Asia. It abounds with innumerable remains of marine ani-

mals, not one of the species of which is now known in the seas of the globe. Above it, at an era of inconceivable antiquity, began to be formed another series of deposites termed Tertiary; but before referring to these, we shall turn for a moment to the agricultural character of the soils of igneous or volcanic rocks.

There are no recent volcanic rocks in the British Islands. Those ancient ones which exist, are of very general distribution in the older secondary groups. Sometimes they form vast isolated rocks, sometimes low hills in long chains, and sometimes abrupt unconnected eminences. They have very generally received the name of trap-rocks, because they often present the appearance of traps or stairs. The most prevalent of them in this country may be classed thus :—

1. A series of clayey rocks, of various colours and hardness, of which the principal are, wacké, claystone, felspar, and clinkstone.

2. Basalt, a rock of a dark-gray colour, frequently forming columns of surpassing regularity and beauty, as at the Isle of Staffa, the Giants' Causeway, and elsewhere. It often extends in long ridges of terrace-shaped cliffs, or forms the caps of mountains, assuming a conical or a tabular form.

3 Greenstone, sometimes columnar like basalt, but less frequently so. It is the common whinstone of this country.

The trap-rocks consist of silica, alumina, lime, magnesia, the alkalies, the oxides of iron and manganese, and some other bodies. They sometimes decompose slowly, and yield a thin unproductive soil; and sometimes they decompose very readily, and form a fertile soil, usually of the lighter class. No general character, therefore, can be assigned to the soils formed by the decomposition of traps in this country. The soil of certain traps is often good, even on the tops of mountains, and eminently so in the hollows to which the abraded particles have been carried.

The chalk, it has been said, forms the last of the formations termed Secondary. The vast system of formations which now succeeds is of surpassing interest in the geological history of the world. Thousands of ages may have elapsed since its members began to be deposited on the submerged surface of the chalk; and

during this period the earth has been gradually approximating to the state which it now exhibits in the conditions which have adapted it to its present inhabitants.

When we regard the oldest of these vast series of depositions, we find the dawning, as it were, of the present order of Nature. Only a few fossil remains of animals can be identified with species now existing, and these consist of the lower tribes, chiefly the testaceous mollusca, or soft animals enclosed in shells, whose external coverings have remained after the softer parts have decayed, or left their impressions in the matrix in which they had been imbedded. Of the higher orders of animals, not one of the species can be identified with any now existing, and several even of the genera and tribes have disappeared.

The oldest of these tertiary formations existing in England, are termed the Plastic and London Clays. It has been proposed by a distinguished geologist of our own country, to refer their deposition to an epoch which he terms the Eocene, indicating the first grand period in the geological history of the formations subsequent to the secondary.* In the depositions of this period, both in this and in other parts of Europe, only about three and a half in the hundred of all the testaceous mollusca discovered, can be identified with any of the species now known to naturalists as inhabiting the present seas. Of other animals, we find amazing remains, imbedded in the clayey, sandy, and calcareous beds of these deposites; but not one of them, so far as is yet known, is identical with any which now exist. The lower formations, both in this country and in France, have been examined by naturalists with astonishing care, and a train of facts has been unfolded, with relation to the past inhabitants of the globe, more wonderful than the dreams of fancy had shadowed forth.

The Plastic clay of England consists of beds of sand, gravel, and clay, alternating with one another. The formation runs along the margin of the chalk in an irregular ring, bounding the whole of the London clay, which forms the greater part of the counties

* Lyell's Principles of Geology.

of Middlesex and Essex. It likewise partially surrounds another basin of the London clay at the New Forest of Hampshire. The clay of this formation is exceedingly aluminous, yielding brick, potters' clay, and fullers' earth. The sand, when it comes to the surface, is usually very barren, forming unreclaimed heaths and wastes; but in other cases, when mixed with the debris of the clayey beds, it forms good light loams. Very different kinds of soil, then, exist in this formation, according as the subjacent beds shall be sandy, clayey, or calcareous, or according to the kind and degree of the mixtures which have taken place.

The London clay forms the greater part of the counties of Middlesex and Essex, a considerable part of Suffolk, and a part of Berkshire, Surrey, and Kent. A basin of it likewise appears at the New Forest of Hampshire, forming what is called the Isle of Wight Basin. The soil of the London clay is, for the most part, exceedingly tenacious. It is highly enriched, in many cases, by the refuse matter of the vast capital and populous towns which are placed upon it. It is extensively covered with rolled flints and other debris of the surrounding formations, often to a great depth. Some of these superimposed deposites are fertile on the surface, and some of them are eminently barren. Although, therefore, the London clay may be generally described as producing a tract of stiff intractable clays, there are found in it, as in every other of the tertiary formations, the greatest variety of soils, with respect to texture, constitution, and productive powers.

Above the most ancient of the tertiary formations, the long ascending series of others more recent present themselves, indicating, by their position and fossil remains, a progressive approach to the present condition of the earth, with respect to its living inhabitants. The periods of time required for these vast mutations are wholly unknown, and scarcely to be measured by our ordinary conceptions of duration. We find, however, the proportion of fossil remains (taking the testaceous mollusca as our standard) gradually approaching in number to the existing species, until it reaches one-half or more. But the stream of time has continued to

roll on, until the period in which we live, with changes less, doubtless, in degree, yet similar in kind to those which occurred in the earlier epochs. The most recent changes are those which we can yet see to be in progress, namely, the carrying of sediment by rivers into the adjoining seas, and the formation of deltas, the filling up of lakes, the formation of peat on the land, and of coral reefs in the ocean, the additions of matter to the surface by subterranean springs and active volcanoes, and other accumulations, the result of causes seen to be in operation. We cannot define the limits of this epoch, but, with relation to those which precede it, we may call it Recent, or Supratertiary. Assigning to this period a sufficient duration, we may say that in it, the animals, whether of the land or seas, have gradually occupied their present habitats; and that in it, one genus, the most noble and important of all, Man, has been called into existence.

Of the great natural agents which have changed the condition of the surface, the most important, it has been seen, is water, which has levelled the mountains, hewed out valleys, and carried the debris of the land to the ocean. When the atmosphere was greatly more charged with aqueous vapour than now, and before the waters of the globe were confined to their present reservoirs and channels, whether of seas or rivers, it may be believed that these waters would overspread a wider space, and, by the bursting open of new channels, sweep over the land with violence. Accordingly, we everywhere see the effects of floods on the surface of the earth. In many cases, sand and gravel, and rounded rocks, have been spread all over the plains, and sometimes over the higher grounds, forming a covering of looser matter, overspreading the stratified deposites often to a great depth. Great tracts of land have, from time to time, been submerged by these torrents, and some of them have occurred within the historical era. But the greatest and most extensive must have taken place before the waters of inland countries had hewed out the existing valleys, and formed for themselves settled courses. That the periods of some of these changes are vastly remote, appears from this,—that the debris everywhere en-

close the remains of animals whose species are now extinct, as of mammoths, or extinct species of the elephant, tapirs, and formidable carnivora.

It was long usual to refer all these changes to the universal deluge of Scripture, and to term the debris Diluvial, in contradistinction to the more recent, though often, in truth, the more ancient, which have been termed Alluvial. But the great deluge of Scripture was a miracle, and must have occurred long posterior to most of those great actions of water which have modified the surface of countries. From the description of the deluge in the Sacred Writings, it seems to have been a gradual rise and subsidence of waters, which left the plants, even to the leaf of the olive, which the dove of Noah brought to the Ark, on the earth. But of those other great actions of water of which we speak, many must have swept over the countries which they submerged in resistless torrents, destroying or burying every plant upon the surface. It must not be imagined, then, that the narration of these grand natural changes, of which every part of the earth bears the indubitable traces, impugns in the least point the authority of those Sacred Records which have been vouchsafed by a gracious Providence to the human race.

With respect to the agricultural character of the soils produced from the tertiary and supratertiary deposites, it has been seen, that, in the case of the oldest, the London and Plastic Clays, no general rule can be given for determining their characters, whether with relation to their texture, their composition, or their productiveness. The formations superior to these, again, are equally incapable of being reduced to any law, with relation to the soils formed upon the surface. Sometimes the soils are exceedingly fertile, as in the case of those muddy flats formed at the mouths of such rivers as the Ouse, the Humber, or the Thames, or of those wide valleys in which the carses of Scotland have been formed; but even in the midst of these rich deposites, infertile tracts occur often of considerable extent. In the counties of Norfolk and Suffolk, which are wholly tertiary and supratertiary, we shall find every kind of soil, from the deep clay of the lower grounds to the

heathy moors of the higher; and everywhere peat, drifted sand, and rolled pebbles, are to be found in the richest districts, rendering the surface barren.

It will now be seen that the relations which we can trace between the mineral deposites of a country and the character of the soil, are often uncertain and obscure. When, indeed, we regard a considerable tract of land, we can, for the most part, trace a connexion between the subjacent deposites and the subsoil, and consequently the soil. Thus, in a country of sandstones and arenaceous beds, we shall find the soil sandy; in one of limestone, more or less calcareous; in one of schistose rocks, more or less clayey. But even in tracts of the same geological formation, there exist great differences in the upper stratum, arising from the prevalence of one or other member of the series, or from the greater or less inclination of the strata, by which the debris of the different beds are more or less mixed together on the surface. The action of water, too, in denuding the surface at one part, and carrying the debris in greater or smaller quantity to another, exercises everywhere an important influence on the characters of soils. Thus, the fertility of a soil on the higher grounds, from which the earthy particles are washed, is found to be very different from that of the valleys to which these particles are carried. It is seen, accordingly, that, within the limits of the same geological formation, soils are greatly varied, and that the mere knowledge of the formation will not enable us to predicate the character of the soil of any given tract, either with respect to its texture, its composition, or its productiveness. The primary rocks, the most constant of any in their characters, yet yield soils of very different properties, under the different conditions to which they may be subjected. Thus the rocks, which, in the mountains of Argyleshire, are so barren, yield in the islands of the Channel a soil of high fertility. The transition rocks in this country are indeed generally infertile and uncultivated; but this is not because they do not contain the elements of fruitful soils, but because they form tracts of mountains. In the east of Jersey, around the town of St Helier, the transition rocks yield one of the most fertile soils of the country; and if we

pass over to Normandy, we there find the finest soils of the province derived from the primary and transition rocks. The old red sandstone, it has been seen, presents soils, from the most barren to the most fertile. The coal formation produces every diversity of soil, from the clays of the ferruginous hills to the loams of the lower country. The new red sandstone is the most continuous tract of fertile land of the same extent in England; but the new red sandstone is a district of plains and valleys, following the course of rivers; and yet, even within the limits of the new red sandstone, are tracts so barren as to be left uncultivated. The lias, although a tract of clays, presents no uniform character with respect to fertility; and the soils of the oolites are so varied, as not to admit of being classified according to their economical value; and similar remarks apply to all the geological formations down to the most recent.

We see, therefore, that the mere knowledge of the geological formations of a country does not afford the data for determining the nature and properties of the soils in the manner required for practice. Speculative writers, indeed, have maintained, that a knowledge of geology is not only eminently useful to the practical farmer, but even necessary to enable him to distinguish soils, and adopt the suitable means of improving them. But the farmer, as all experience shews, can distinguish soils for his own purposes, by their agricultural characters, much more certainly and readily than the geologist can by their geological; and it does not appear in what manner geology can give that knowledge to a farmer which can enable him to cultivate and improve his land. The farmer, it is manifest, must regard the soil which he has to till, not in its relations with a whole district, but with reference to its own characters and fertility. He may find the soil not only of a single farm but of a single field, varying in every degree; and it will be necessary that he adapt his management to these variations, whatever be the geological formation in which he may be placed. It were greatly to be desired, indeed, that the practical farmer could acquire a knowledge of geology, and learn to read a portion of

that marvellous history which is written on every rock and mineral bed around him. Such a knowledge would give a charm to rural pursuits, and connect a liberal and interesting study with the observations of daily life; yet such a knowledge, however excellent, will not enable the farmer to discriminate soils better for the ends of practice, much less enable him to cultivate them with greater skill, which is knowledge he must derive from agriculture, and not from geology.

IV. THE PROPERTIES OF SOILS, AS DETERMINED BY THEIR VEGETABLE PRODUCTIONS.

When we regard the distribution of plants in different regions, we perceive that this is determined by causes which have little relation to the nature of the soil on which the plants grow. The soils of all countries are, in their essential characters, alike. The same mineral masses, composed of the same substances, exist over all the world, and yield, by their disintegration or decomposition, the same materials for the formation of soils.

But although the mineral matter of the soils of all countries is thus similar in its constituent parts, it is altogether different with the vegetation by which these soils are characterized. Every zone, from the equator to the polar circle, is distinguished by a different vegetation; and different regions have their peculiar plants. A district of granite, of sandstone, or trap, in southern Asia, will yield the same materials for forming soils as similar districts in northern Europe, while the vegetation produced will scarcely possess any common character.

Amongst the natural causes which affect the vegetation of countries, the influence of temperature is that which is the most obvious to the senses. When we pass from a warm country to a cold, we perceive a change in the whole character of the vegetation. We cannot ascend a mountain without finding such a change in the kinds of plants produced, and in the vigour with which they grow,

dependent upon the change of temperature. The degree of moisture, too, the distance or proximity of the sea, and other circumstances connected with the climate and physical condition of the country, affect the nature of its vegetable productions, and shew that the influence of soil, with respect to the kinds of plants produced, is entirely subordinate to that of temperature and the effects of climate.

When we extend, then, the range of our observation to different and distant countries, we see that the nature of the plants cannot indicate that of the soils on which they grow. It is only within narrow limits, and under given conditions of climate, that the kinds of plants afford any indication of the nature of the soils which produce them.

Within certain geographical limits, however, as those of a country having throughout nearly the same climate with respect to temperature and humidity, useful rules may be given for distinguishing soils by means of the plants which they produce. Numerous species of plants, indeed, will grow with equal readiness on different kinds of soils; yet there are other species which affect particular soils, and in their wild state do not grow on any other. Thus, there are plants whose natural habitat is peat, others which grow on soils charged with moisture, and others on soils which are dry; some which, under the like conditions of humidity and temperature, are proper to the light and siliceous soils, some to the stiff and argillaceous, and some to the calcareous.

But, as even within the limits of a single country, nearly similar in its climate throughout, variations must exist of altitude, and, consequently, of temperature,—of exposure to particular winds, and, consequently, of humidity,—of proximity or distance from the sea,—and other circumstances affecting the habitats of plants,—it is often difficult to indicate the precise nature of a soil merely by its prevailing vegetation. It is almost always possible, however, to determine from this circumstance, whether the soil be wet or dry, and whether it be fertile or infertile.

It is for the last mentioned purpose, namely, determining the

character of a soil with respect to its fertility, that the examination of its vegetable produce is the most important in practice. The nature of a soil, with regard to its texture and other physical characters, will generally be best determined by an examination of the substance itself. But its fertility, or power of production, may be judged of from its natural produce; in part from the kinds of plants which are peculiar to it, and in part from the luxuriance with which they grow.

When we cast the eye over a tract of country, we have generally little difficulty in determining whether it be barren or fertile. The general aspect of the vegetation, whether stunted or vigorous, the absence or presence of heaths, the richness of the sward, the cleanness and straightness of the stems of trees, the verdure of the foliage, and the like, present to the eye a general character not easily to be mistaken.

When we observe a tract covered with luxuriant grasses and other plants, and with vigorous shrubs and trees, we naturally associate these appearances with fertility in the soil itself. When, again, we see a tract of heaths or naked sands, with the plants small or sickly, the soil thinly covered with lichens, mosses, and other inferior plants, the eye alone is sufficient to indicate that the tract is absolutely or relatively infertile.

The same method of judging of the productiveness of the soil may be extended to a field or to a farm. Let us direct the eye over it, and its general character with relation to its vegetable productions, will impress us at once with an idea of its fertility or barrenness.

This conclusion, indeed, will not be so securely arrived at if the surface be limited to a single field, and still less if that field be cultivated, in which case the effects of art, and the stimulus of cultivation, may disguise the natural characters of the soil. But if the range of our observation shall be so extended as to take in a sufficient number of fields and objects, such as trees, shrubs, hedges, and natural meadows, we shall scarcely fail, if the eye be at all accustomed to country objects, to arrive at a tolerably correct con-

clusion as to the general character of the soil with respect to fertility ; and our conclusions will be yet more satisfactory and precise, if we know the particular kinds of plants which thus give the character of infertility or productiveness to the soil.

The plants, the most important in this species of examination, are the heaths, the grasses, and other herbage plants. In the vast forests of the New World, a common method resorted to by settlers for judging of the comparative productiveness of soils, is by observing the kind of trees produced, whether pine, cedar, hickory, or oak. This is because the principal vegetable productions of these countries are wood. But with us the principal vegetable productions are the heaths, the grasses, and other plants that form the sward. These may be said to cover the entire surface of the country when not extirpated by art ; and they afford, accordingly, the readiest means which vegetable productions present of judging of the properties of soils.

The fertility of soils, generally speaking, is denoted by their power to yield the useful plants ; and it is a law, with few exceptions, that the poorer the soil is, the less nutritious are the plants which, in its natural state, it produces. The soils of the poorest class produce mosses, lichens, and heaths, which are less nutritious than the grasses. As the soil improves in quality, the grasses become intermixed with the heaths, lichens, and mosses. But the grasses are still inferior and little nutritious. As the soil continues to improve, the grasses become more valuable in their kind, and more numerous in their species ; and, in like manner, the leguminous and other herbage plants indicate, by their kinds and greater numbers, the increasing fertility of the soil. A square foot of rich old turf has been found to contain 1000 separate plants of twenty distinct species ;* while a square foot of siliceous sand will frequently contain not more than half a dozen distinct plants, and those of a single species.

In the northern latitudes of Europe, the plants most generally regarded as indicative of inferior soils are the heaths. Some of

* Hort. Gram. Woburnensis.

the species of this family characterize, in a peculiar manner, the soils termed peaty. They are found, too, abundantly, on the coarser clays or tills, on the poorer siliceous sands, as those lying upon or derived from quartz, on the poorer class of calcareous soils, as chalk, and generally on all soils low in the scale of fertility.

The soils where this kind of plant prevails, are frequently termed heathy soils, or heaths. Heathy soils have, however, their relative degrees of productiveness, and this is generally well denoted by the vigour with which the heaths peculiar to them grow. Thus, a soil of stunted heaths may be regarded as amongst the lowest in the scale of fertility, whilst a vigorous growth of the plant may indicate a soil susceptible of improvement and cultivation.

The principal heaths of this country are :—

1. Calluna vulgaris—Common Ling ;
2. Erica cinerea—Fine-leaved Heath, indicative of a dry soil ;
3. Erica Tetralix—Cross-leaved Heath, indicative of a wet soil ; and two other species more rare and local.

Intermixed with heaths, and indicating, like them, soils low in the scale of fertility, are numerous plants. Such are—

1. Many species of Lichens, as
   Cladonia rangiferina—Rein-deer Moss, and
   Cetraria islandica—Iceland Moss.
   Which two species form an exception to the more common law, by being nutritive, though produced on inferior soils.
2. Empetrum nigrum—Black Crowberry or Crakeberry.
3. Salix fusca—Dwarf Silky Willow.
4. Lycopodium clavatum—Common Club-moss.
5. Genista anglica—Needle Greenwood or Petty Whin, &c.

And many of the inferior grasses, as—

1. Melica cœrulea—Purple Melic-grass.
2. Nardus stricta—Mat-grass.
3. Agrostis vulgaris—Fine Bent-grass.
   And various Carices and Junci—plants of an inferior kind, with respect to their nutritive powers.

All these species of plants indicate soils low in the scale of fertility.

But although peaty soils produce these and other inferior herbage-plants, yet there are plants still more distinctive of this class of soils, and which, growing only upon it, may be said to be the true plants of peat. Such are—

1. Certain species of Sphagnum, of which the most common are :—
   Sphagnum obtusifolium—Blunt-leaved Sphagnum.
   Sphagnum acutifolium—Sharp-leaved Sphagnum.
   By the decay of which species, the great mass of peat appears to be formed in certain countries.
2. Eleocharis cæspitosa—Scaly-stalked Spike-rush.
3. Polytrichum commune—Common Polytrichum.
4. Different species of Eriophorum or Cotton-grass, namely—
   Eriophorum vaginatum—Hare's tail Cotton-grass.
   Eriophorum polystachion—Broad-leaved Cotton-grass.
   Eriophorum angustifolium—Common Cotton-grass.
5. Narthecium ossifragum—Lancashire Bog-asphodel, &c.

These and other plants growing only on peat, indicate great infertility.

Another class of plants indicating extreme dryness of the soil, also consists of plants denoting infertility. Such are—

1. Galium verum—Yellow Bedstraw.
2. Galium saxatile—Smooth-headed Bedstraw.
3. Campanula rotundifolia—Round-leaved Bell-flower or Harebell.
4. Aira præcox—Early Hairgrass.
5. Aira caryophyllea—Silvery Hairgrass.
6. Aira cristata—Crested Hairgrass.
7. Arenaria rubra—Purple Sandwort.
8. Hieracium Pilosella—Common Mouse-ear Hawkweed.
9. Linum catharticum—Purging Flax.
10. Rumex acetosella—Sheep's-sorrel.

There is also a class of plants which indicate wetness of the soil. These plants, however, do not necessarily indicate infertility, because, in numerous cases, soils, though charged with moisture, are naturally fertile. Of the first kind, namely, those indicating infertility, as well as moisture, the following are examples :

1. Juncus squarrosus—Heath-rush.
2. Juncus acutiflorus—Sharp-flowered jointed Rush.

3. Lychnis Flos-Cuculi—Meadow Lychnis or Ragged Robin.
4. Ranunculus Flammula—Lesser Spearwort.
5. Cnicus palustris—Marsh Plume-Thistle.
6. Cardamine pratensis—Common Meadow Lady's-smock.
7. Pinguicula vulgaris—Common Butterwort.
8. Pedicularis sylvatica—Pasture Louse-wort or Dwarf Red Rattle.
9. Triglochin palustre—Marsh Arrow-grass.
10. Galium palustre—White Water Bedstraw.
11. Rhinanthus Crista-Galli—Common Yellow Rattle.

And various species of Carex, &c.

The plants which have been mentioned, indicate infertility and wetness of the soil; others shew that the soil is wet, but do not necessarily indicate that it is infertile. Such are—

1. Agrostis alba—March Bent-grass or Fiorin.
2. Poa fluitans—Floating Meadow-grass.
3. Poa aquatica—Reed Meadow-grass.
4. Arundo Phragmites—Common Reed.
5. Alopecurus geniculatus—Floating Foxtail-grass.
6. Catabrosa aquatica—Water Whorl-grass.
7. Equisetum arvense—Corn Horsetail; and other species of Equisetum.
8. Veronica Beccabunga—Brooklime.
9. Polygonum amphibium—Amphibious Persicaria.
10. Stachys palustris—Marsh Woundwort.
11. Juncus effusus—Soft Rush.
12. Juncus conglomeratus—Common Rush; and many other species of plants.

Certain plants are held to indicate infertility where they prevail, without being peculiar either to a very wet or very dry situation. Such are—

1. Euphrasia officinalis—Eyebright.
2. Prunella vulgaris—Self-heal.
3. Aira cæspitosa—Turfy Hair-grass.
4. Triodia decumbens—Decumbent Heath-grass, &c.

Certain plants indicate a maritime situation. Such are—

1. Ammophila arundinacea—Common Sea-Reed or Matweed.
2. Carex arenaria—Sea Carex.
3. Elymus arenarius—Upright Sea Lyme-grass.
4. Triticum junceum—Sea Rushy Wheat-grass.
5. Statice Armeria—Thrift or Sea Gilliflower, &c.

Various plants are regarded as indicating fertility where they prevail. Of these are—

1. Cnicus lanceolatus—Spear Plume-Thistle.
2. Urtica dioica—Great Nettle.
3. Arctium Lappa—Common Burdock.
4. Stellaria media—Common Chickweed.
5. Achillea Millefolium—Common Yarrow.

And generally speaking, all the richer and more nutritious pasture grasses. Such are—

1. Dactylis glomerata—Rough Cocksfoot.
2. Festuca pratensis—Meadow Fescue.
3. Alopecurus pratensis—Meadow Foxtail.
4. Poa trivialis—Rough-stalked Meadow-grass.
5. Lolium perenne—Ryegrass.

Those who desire to pursue these investigations more in detail, may consult botanical works descriptive of the plants of particular countries or districts, in which they will find the habitats of plants indicated with more or less correctness. It is not necessary, in the present place, to extend the observations on this subject; for in giving examples of plants, those have been selected which are of frequent occurrence, and the best suited to indicate the characters of soils in this country.

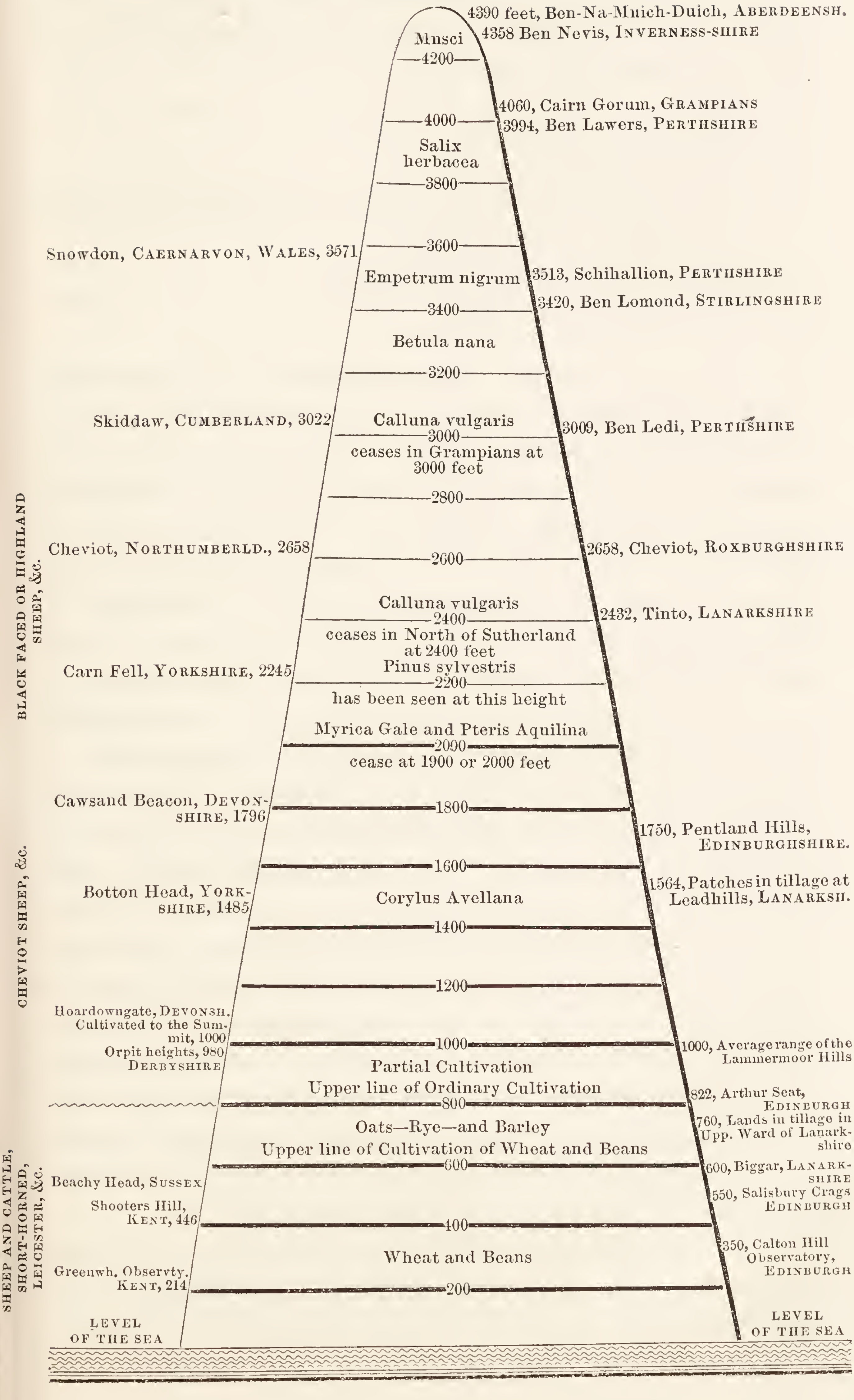
V. THE PROPERTIES OF SOILS, AS DETERMINED BY CLIMATE AND ALTITUDE.

The soils of countries, however distant, must, with respect to their mineral constituents, be nearly alike; for everywhere the crust of the earth is composed of the same mineral masses, and everywhere the like waters and air act upon these masses, and reduce them to soils. But although the same matter forms the basis of all soils, from the polar circle to the equator, yet wholly different are the soils produced, with relation to their fertility and vegetable productions. While, in the higher latitudes, a district of

granite and the primary rocks may produce only pines, heaths, and feeble mosses, a similar district in the warmer regions may be covered with palms, fig-trees, arborescent ferns, and the richest produce of a tropical clime. If we shall look at the hot-houses of our gardens, we shall see the soil which, in the air without, produces only the plants proper to the climate, yielding, under the influence of increased temperature, the richest fruits and gayest flowers of the tropics.

Not only has every zone, from the torrid regions to the frozen, its peculiar vegetable productions, but within the same zone, and in the same country, the vegetable productions are dependent on the influence of temperature. If we ascend from the plain to the mountain, we shall behold the vegetation vary with every increase of altitude. In the vast mountains of intertropical regions, we find, at the base, the vegetable productions of a moist and burning climate—the palm, the banana, and the banyan; ascending, we reach the region of the walnut, the lime, the oak; yet higher, we come to the birch, the pines, and other productions of northern climates; and, towards the summit, to the mosses and lichens of the frozen zone. And, in like manner, in every country, we shall find, that, as we change our climate by ascending, a new vegetation, varying with the change of temperature, presents itself. Within the narrow limits of our own country are found all the intermediate degrees between fertility and barrenness of soil, dependent upon altitude. The great mass of the cultivated soil of the British Islands lies below the level of 600 feet; and 800 feet may be considered as the upper line of ordinary cultivation, beyond which tillage is partial, and quickly ceases. Ascending, all the grasses, rushes, sedges, and even the hardiest of the heaths, progressively disappear, until we reach at length an elevation at which vegetation ceases altogether, or at which only mosses and flowerless plants are produced. The rapid change of temperature produced as we ascend above the level of the lower grounds, and the controlling influence of altitude on the productiveness of the soil, will appear from the following diagram:—

Fig. 3.


4390 feet, Ben-Na-Muich-Duich, ABERDEENSH.
4358 Ben Nevis, INVERNESS-SHIRE
Musci
4200
4060, Cairn Gorum, GRAMPIANS
4000
3994, Ben Lawers, PERTHSHIRE
Salix herbacea
3800
Snowdon, CAERNARVON, WALES, 3571
3600
Empetrum nigrum
3513, Schihallion, PERTHSHIRE
3400
3420, Ben Lomond, STIRLINGSHIRE
Betula nana
3200
Skiddaw, CUMBERLAND, 3022
Calluna vulgaris
3000
ceases in Grampians at 3000 feet
3009, Ben Ledi, PERTHSHIRE
2800
Cheviot, NORTHUMBERLD., 2658
2600
2658, Cheviot, ROXBURGHSHIRE
Calluna vulgaris
2400
ceases in North of Sutherland at 2400 feet
2432, Tinto, LANARKSHIRE
Carn Fell, YORKSHIRE, 2245
Pinus sylvestris
2200
has been seen at this height
Myrica Gale and Pteris Aquilina
2000
cease at 1900 or 2000 feet
Cawsand Beacon, DEVONSHIRE, 1796
1800
1750, Pentland Hills, EDINBURGHSHIRE.
1600
1564, Patches in tillage at Leadhills, LANARKSH.
Botton Head, YORKSHIRE, 1485
Corylus Avellana
1400
1200
Hoardowngate, DEVONSH. Cultivated to the Summit, 1000
Orpit heights, 980 DERBYSHIRE
1000
1000, Average range of the Lammermoor Hills
Partial Cultivation
Upper line of Ordinary Cultivation
800
822, Arthur Seat, EDINBURGH
Oats—Rye—and Barley
Upper line of Cultivation of Wheat and Beans
760, Lands in tillage in Upp. Ward of Lanarkshire
600
Beachy Head, SUSSEX
600, Biggar, LANARKSHIRE
550, Salisbury Crags EDINBURGH
Shooters Hill, KENT, 446
400
Wheat and Beans
350, Calton Hill Observatory, EDINBURGH
Greenwh. Observty. KENT, 214
200
LEVEL OF THE SEA
LEVEL OF THE SEA
BLACK FACED OR HIGHLAND SHEEP, &c.
CHEVIOT SHEEP, &c.
SHEEP AND CATTLE, SHORT-HORNED, LEICESTER, &c.

The conditions which influence the climate of countries are various. The principal of them may be comprehended under the following general heads :—

1. Latitude.
2. Altitude and aspect.
3. The relations of a country with the adjoining seas, and with the lands of other countries.
4. Humidity and the prevailing winds.
5. The nature of the surface.

1. With respect to the effects of latitude, it is a general law, though greatly modified, that countries shall be colder as they recede from the equator to the poles. This is caused mainly by the less direct action of the sun's rays, which, impinging on the surface obliquely, are reflected and not absorbed. But, from the inclined position of the earth's axis, the day in summer increases in length as countries recede from the equator ; and this is a grand provision in nature for making compensation in part for the effects of diminished temperature, and rendering the higher latitudes habitable ; for, by this means, the heat communicated to the earth during the day is greatly increased, and the processes of vegetation proceed with less interruption from the absence of light ; and thus plants the most necessary to man are brought to maturity during a brief period of heat and sunshine. It is thus that the inhabitants of the extreme north of Europe are enabled to cultivate several of the cereal grains almost as well as in the lower latitudes. We derive supplies of corn from Archangel, which approaches the limits of useful vegetation in Europe ; and in the northern parts of Scandinavia, nearly ten months of the year are ice and snow, and yet a brief and fiery summer of long days enables the inhabitants to cultivate barley, oats, rye, and other useful vegetables. But yet, with the decrease of the mean temperature, the power of the earth to produce different plants continually diminishes.

2. The other conditions referred to as affecting climate are altitude and aspect. The cause of that progressive decrease of temperature which takes place as we ascend, is mainly due to the

physical properties of the atmosphere. The air below is pressed upon by that which is above, and the higher we ascend the less is the pressure. In proportion, therefore, as we ascend, and as the pressure from above becomes less, the air tends to expand, and becomes more and more rarefied. This decreasing density of the air, combined with that property of heat by which it becomes continually less sensible as a body increases in volume, is the cause that the air becomes colder in a rapidly increasing ratio as we ascend. This effect is so great, that even in those zones of the earth in which the rays of the sun are the most direct and powerful, we quickly, in ascending, reach a point at which the cold is intense. At the equator, the height of the line of perpetual congelation is only about 15,000 feet; and it only becomes lower toward the higher latitudes, until at the poles it may be considered as level with the sea. At the latitude of the south of England, it is about 6000 feet; and in Scotland it is so much lower, that the summits of the highest mountains just fall beneath it. Thus nearly do we approach in the British Islands to the region of perpetual frost, far beneath the lower limits of which all useful vegetation has ceased.

Analogous to the effect of altitude on temperature is that of aspect. If a tract of land is inclined towards the sun, the rays will strike it more directly than if it is not inclined towards the sun. Nay, the plane of its surface may be so far turned away that the direct solar rays shall not strike it at all. In the colder countries, the sides of mountains exposed to the sun are often intensely heated; while the other side, which the sun's rays do not strike, or which they strike very obliquely, is wrapped in perpetual winter. In the Alps, towards the plains of Italy, it is common to see one side of a mountain covered with never-melting ice, and on the other, vineyards, cultivated fields, and all the beauty of the richest summer. The vast plains of Northern Asia incline to the North, and this, in conjunction with other causes, produces an intensity of cold in latitudes which would otherwise produce an almost perpetual verdure.

3. The relations of a country with the adjoining seas, and

with the lands of other countries, have an important influence on climate.

The temperature of the sea is greatly more uniform than that of the land. When the prevailing winds of a country, therefore, blow from the sea, its temperature will be more equal than when they blow from the land. It will be less cold in winter, and less warm in summer. This circumstance influences greatly the climate of Europe, and in an especial degree that of the British Islands.

Again, the position of a country with respect to the lands of other countries, may vastly modify its climate. Let it be imagined that a country is placed near another whose surface is wholly or partially within the limits of perpetual congelation,—then, when the winds blow from the cold and frozen region, they immediately communicate the cold of the higher country to the lower, and produce an effect upon the temperature of the lower country in proportion to the constancy with which they blow from the higher.

This circumstance has a mighty influence upon all the climates of northern countries. Near and within the arctic circle, a vast accumulation of ice has taken place, which never yields to the influence of heat. The winds that blow from these frozen regions affect all the countries which they reach.

Europe, with respect to this vast magazine of ice and snow, is happily situated, because it has an ocean between it and the arctic regions; and Great Britain is yet more favourably situated than countries of the same latitude on the continent of Europe, because the northern winds must pass over a long space of sea before they reach it.

But along the vast and elevated plains of Northern Asia, which communicate with the lands of the arctic regions, the rigour of the north wind is intense, and that in latitudes far to the south of ours. This gives rise to extremes of temperature, which the inhabitants of Europe never experience. Pekin is in the latitude of Sardinia, and yet the winter of Pekin is more severe than that of the highest inhabited land of the Highlands of Scotland. Hum-

boldt remarks, that, with a summer more hot than that of Cairo, the winter is more rigorous than that of Upsal in Sweden. The same intensity in the extremes of temperature prevails over Chinese Tartary, and a great part of the Russian Empire in Asia. And when we turn to the New World, the effects of this contact with the frozen regions of the north is not less remarkable. In North America, within latitudes which would comprehend the mildest climates of Europe, a degree of cold prevails, which, for a part of the year, is excessive. The finest parts of England lie within the same latitudes as the frozen regions of Labrador and Hudson's Bay. In latitudes in which, in Europe, snow is scarcely ever seen, the largest American rivers are frozen over in a night. In the midst of summer, should a north wind arise, the temperature is in an instant changed to the cold of winter. At New York, says Humboldt, we find the summer of Rome and the winter of Copenhagen; at Quebec, the summer of Paris, and the winter of St Petersburg.

4. The humidity and prevailing winds of a country exercise likewise an important influence on climate.

There exists continually in the air of the atmosphere a quantity of aqueous vapour. This quantity is not constant, but varies with the temperature of the air, and the degree of evaporation from the surface of the earth and seas. This vapour of the atmosphere is invisible, and only becomes apparent to the senses when condensing in clouds, mists, dews, and other watery meteors. In the warmer zones the air is vastly more charged with this invisible moisture than in the colder, and this is a bountiful provision of Nature; for plants are thus supplied in the greatest degree with moisture from the atmosphere, when it is most rapidly evaporated from the surface. Rain is merely the precipitation from the atmosphere of the water which the air holds in solution, and snow is frozen water. Of the causes which produce a rapid deposition from the atmosphere, one, the most commonly assigned, is the mixing together of currents and masses of air of different temperatures, by which means their common temperature is so lowered that the excess of aqueous vapour is necessarily thrown

down. The direction and constancy of the winds of particular regions have therefore an important influence in causing the deposition of rain from the atmosphere.

In the torrid zone, the winds, from causes unnecessary to be here explained, have a wonderful degree of constancy, and only change at fixed seasons. The water of the atmosphere is therefore only thrown down in quantity at particular periods, producing the distinction of the dry and rainy seasons. But then the quantity is very great, far exceeding that which is produced in the drier air, and with the more varying winds, of higher latitudes. But even in the warmer regions, the currents of winds are sometimes so modified and deflected, that rain scarcely ever falls in particular places. Thus, in the valley of the Nile, rain is so rare as to be looked upon as a remarkable event, and over many hundred miles of plains in South America no rain ever falls, all the moisture required by growing plants being supplied by the dew.

In the higher latitudes, the currents of wind are greatly more inconstant than in the lower, and masses of air of different temperature being continually intermingled, falls of rain are more frequent. Mountains intercept the clouds, and on the elevated grounds a greater quantity of rain falls than in the plains. Not only the elevation of a tract of country, therefore, but its position with respect to the neighbouring mountains, has an influence on the humidity of the climate. On one side of a range of mountains, the climate may be comparatively moist, and on the other, towards which the prevailing winds blow, it may be comparatively dry; nay, particular valleys and narrow tracts may be more or less frequently visited with rains, according to the degree in which the currents of wind are deflected by the neighbouring heights. Even within the limits of a narrow country, therefore, there are tracts in which the climate is more or less humid.

On all the western shores of the British Islands, towards which the westerly winds, charged with the vapours of the Atlantic, blow, a much greater quantity of rain falls than on the eastern. While, at Edinburgh, the mean annual fall of rain is estimated at 24 inches, at Kendal, in Westmoreland, it is calculated at 56. This circum-

stance has a sensible influence on the practices of agriculture and the economical value of the soil. The moist climate is more favourable to the production of the grasses and other herbage-plants, while it is less favourable to the ripening and harvesting of the cereal grains.

5. The last of the circumstances to be referred to as affecting climate, is the nature of the surface.

By a law of heat, when bodies change from the solid to the liquid state, or from the liquid to the aëriform, they produce cold. To maintain a body in the liquid state, a quantity of heat is required beyond what is necessary to maintain it in the solid; but this increased quantity of heat is not manifest to the senses, but remains latent or concealed in the body. A body, therefore, in becoming liquid, withdraws heat from the neighbouring matters, and so produces cold. In like manner, when a liquid becomes vapour, it requires a quantity of heat to maintain it in this state, which it did not require to maintain it in the liquid form; and hence a liquid, in becoming vapour, withdraws heat from the neighbouring bodies, which becomes latent in the vapour. When water, therefore, becomes liquid, that is when ice melts, heat is withdrawn from the bodies around, to supply the latent heat of the newly-formed liquid. Again, when a body passes from the state of liquid to that of vapour, it in like manner, but in a far greater degree, produces cold. The evaporation of water, therefore, whenever it takes place from the surface of the earth, causes cold. These phenomena are reversed when vapours become liquid, or liquids solid. The new substances give out again their latent heat, and the surrounding bodies become warm.

All have felt the refreshing coolness produced in the air by a shower of rain in summer. This is caused by the subsequent evaporation of the water, and the consequent withdrawal of heat from the neighbouring bodies. In the polar regions, this giving out of heat when water freezes, and the causing of cold when it melts, produce a highly beneficial effect. When the sun, rising above the horizon, gives to the inhabitants their long day, the heat is intense. Its effects, however, are tempered by the melting of the ice and

snow, which produces cold. And again, when the sun begins to decline towards the horizon before the long and dreary night begins, all the waters freeze. This produces heat, and so the change to the inhabitants, from the summer of their long day to the winter of their long night, is rendered gradual, and supportable by the human frame.

The evaporation of water is continually going on from all the surface of the earth and seas. Countries present surfaces more or less favourable to evaporation, and hence their temperature is more or less affected by the condition of their surface.

A country covered with swamps and lakes sustains a greater evaporation than one which is dry; and hence countries of this character are subject to excessive cold. The rendering of a country dry by art, tends to increase its temperature; and there is known to have been a vast improvement in the climate of countries by the labour of man. In our country, over all Europe where cultivation has extended, and over all America where the forests have been felled, the climate has undergone improvement by the draining off of moisture.

The climate of Europe possesses those characters which arise from difference of latitude, altitude, and other circumstances. Towards the eastern boundary of the Ural Mountains, it partakes of the rigorous climate of Northern Asia; but it becomes more equal, with respect to the extremes of temperature, towards the Atlantic. South of the line of the Pyrenees on the west, and of the Balkan on the east, the climate of Europe is equable and warm, the winds are moderate, and the sky is serene. This region comprehends Spain and Portugal, Italy southward from the Tiber, the finest parts of Turkey in Europe, Greece, and the lovely islands of the Archipelago, Sicily, Sardinia, and the Balearic Isles. Within this delightful zone grow the orange, the citron, the olive, and the vine; and, along with wheat and barley, are cultivated rice, millet, the sugar-cane, and other productions of the warmer latitudes. The natives consume oil in quantity along with their food, and the liquor, except in the Mahomedan States, is wine. Northward from this, which may be termed the region of the olive, to about the 50th

degree of latitude, which just touches the southern shores of England, the vine, though with a less propitious temperature, is largely cultivated. Wheat and barley are the principal cereal grains produced, oats being little used. The liquor of this region is chiefly wine, and the bread is of the flour of wheat; the use of oil diminishes, and the produce of the dairy is partially or wholly substituted. This fine region comprehends northern Italy, France, Switzerland, about one-half of Germany, the countries of the Danube, and the Russian dominions on the Black Sea. From the 50th to the 60th degree of latitude, the mean temperature becomes less, and the climate more variable; the culture of the vine ceases, and the hardier pomaceæ are substituted. In this zone are cultivated wheat, rye, barley, buck-wheat, and oats: rye and buck-wheat supplying the place of wheat in the more northern parts, and oats the place of barley: the liquor of the inhabitants is beer, and butter supplies the place of oil. Here, with a ruder climate, the industry of the inhabitants sometimes gives a greater fertility to a country than the most bountiful gifts of nature elsewhere; witness Holland, the Low Countries, England, and a part of Scotland.

England, or the southern division of Great Britain, possesses a climate more irregular than the rest of Europe in the same latitudes; but the temperature is less in extremes, so that the winters are more mild, and the summers more cool. The climate is likewise more moist, because the prevailing winds are the westerly, which blow over the Atlantic, charged with its vapours. This coolness and moisture combined are unfavourable to the maturing of certain plants, as the vine, which ripens its fruits in a higher latitude on the continent than in England; but it is sufficient for the ripening of the cereal grains, and the most useful plants, on land not too greatly elevated, and it is in an eminent degree favourable to the production of the common grasses. This communicates a lovely verdure to the sward of England, which endures throughout the greater part of the year, and may well console the inhabitants for the gayer flowers and more varied vegetation of southern climes. The climate of England differs with respect to

humidity on the western and eastern sides of the island, the quantity of rain which falls on the former being greatly more than that which falls on the latter.

The same character of comparative humidity and dryness applies to the western and eastern coasts of Scotland, and this with a diminution of the mean temperature, so that the climate of Scotland is more moist and cold than that of England. In spring, the progress of the vegetation is several weeks behind that of the southern and central parts of England; and the harvest of the cereal grains is proportionally retarded.

Ireland partakes of the character of the climate of the west of England, with a yet greater degree of humidity. The summer of Ireland is more cool, and the winter more temperate, than in any country of the same latitude; and this moisture, combined with a medium temperature, renders Ireland peculiarly suited to the production of the grasses and other herbage-plants.

From this cursory examination of the subject of climate, it will appear, that, whatever be the constitution of the soil, its productive powers are essentially affected by temperature and the other conditions of climate. The same soil may be fertile in Devonshire, and comparatively barren in the Western Hebrides; and we should reason altogether erroneously concerning the relative fertility of tracts of country, and the kind of culture adapted to them, were we to omit the consideration of climate and place.

In these latitudes of ours, where the range of useful vegetation is limited to narrow bounds of altitude, the height of a tract of ground above the level of the sea must be seen to form a necessary element in determining its economical value. At the elevation of upwards of 1000 feet, the farmer of these islands must look to pasturage and not to tillage as the means of making good a rent; and when tillage is pursued at such an altitude, it must be chiefly regarded as subsidiary to the raising of food for the animals of the farm. In estimating the value of land, then, for the purposes of tillage, a large deduction must be made on account of its elevation.

The farmer, too, must regard the exposure of his land when he

estimates its adaptation to the raising of particular crops. Many of our most fertile soils incline to the north; but this is less favourable to the ripening of the cereal grains, than when the exposure is towards the sun.

Other circumstances are likewise to be taken into account in judging of the value of any tract of land, as whether it is exposed to the action of particular winds, whether it is naturally or artificially sheltered, whether its climate is dry or humid, whether it is in the vicinity of the vapour of swamps, and whether the surface is steep or level.

Giving the due weight to these, and other circumstances which may affect the economical value of a tract of land, as a field or farm, the following rules may be given for enabling the student to discriminate soils in the situations in which they shall be presented to him.

1. Let him make such use of the indications afforded by the natural produce of the soil, as his means of information may afford. He may not know the names of the plants which are growing upon the surface, but he can always observe whether the sward is thickly covered with species, and whether the general aspect of the part to be examined indicates fertility or poverty.

A difficulty, which it will be well that he endeavour, in the first place, to overcome, is to distinguish the peaty soils from the earthy. He will experience little difficulty in this when they are distinct from one another, and covered by their natural herbage. But when they are subjected to cultivation, or intermingled with the earthy soils of the same field, or when a soil contains a certain portion of peat in its composition, without being entirely peaty, then the eye may be deceived, from the resemblance of peat to the dark-coloured loams. The one class of soils, however, may be of great fertility, and the other very barren: for it is to be observed, that, though peat may be often rendered fertile, its presence in soils is always suspicious.

The soils termed peaty, it was before observed, are dark in their colour, and loose and spongy in their texture, even when improved by art. The soils which they most resemble in exter-

nal characters are the richer loams, but they are more light and spongy, and their colour is of a duller dark, the loams approaching in colour to a hazel hue. Peaty soils, too, very generally lie on a retentive subsoil; but a good method of discriminating them in the absence of their peculiar vegetation, is by the stones which lie upon their surface. These appear to be acted upon by the acid matter of the peat, and present a white appearance, which, when once observed, will not be easily mistaken. Coupling this indication with the dull black, as distinguished from the brighter hazel of the loam, and above all, with the peculiar vegetation and steril aspect of the surface, an observer will soon learn to distinguish the peaty soils from the earthy.

In examining soils, an essential circumstance to be regarded is the depth of the soil, and the texture of the subsoil. A medium depth of a soil may be held to be about twelve inches. But it will be better that it exceed a foot, and this greater depth of the soil is always a favourable indication. If the depth of the soil does not exceed six or eight inches, that is an unfavourable indication. Such shallow soils are rarely good, except sometimes when they occur resting on peculiar rocks, as compact limestone and certain easily decomposed basalts and porphyries. If a shallow soil shall occur on a retentive clay, or on siliceous sand, we may certainly pronounce it to be bad. When, in the common operations of tillage, the plough is constantly turning up a subsoil very different in colour from the upper stratum, that is an unfavourable indication.

When we find the rain in a furrow of ordinary descent carrying off the soil, and leaving the subsoil exposed, that is an unfavourable indication. It is desirable that the water in the furrows shall sink down, and be absorbed, instead of carrying off the surface soil.

If the soil be of a dull black colour, and if it present upon the surface the white stones above referred to, that is an unfavourable indication, as it shews that the soil has more or less of peat in its composition.

If the soil produce sub-aquatic plants, it is wet. If we find

that such a soil is peaty, or shallow on a retentive subsoil, it is naturally steril. If we find that the sub-aquatic plants are tall and vigorous, and the soil earthy and deep, the removal of the wetness may remove the cause of infertility, and such a soil may become of the richest kind.

If we find a soil producing naturally the superior herbage-plants, and of a good depth, we may infer such soil to be good. When a soil of this kind tends to a dark hazel colour, we may safely reckon it amongst the superior soils.

By attention to these rules, and by a little observation and practice, the difficulty of discriminating soils will gradually be lessened, and at length disappear. Those who have been used to country objects rarely experience difficulty in discriminating soils, in so far as these soils are to be distinguished by their texture as stiff and free, or by their powers of production as rich and poor.

V. MEANS OF INCREASING THE PRODUCTIVE POWERS OF SOILS.

The means at our command of increasing the productive powers of soils may be regarded as partly chemical and partly mechanical. They may be comprehended under the following general heads:—

1. Supplying to the soil those earthy and organic substances which may be required.
2. Altering its texture, depth, and properties, by mechanical means.
3. Changing its relation with respect to moisture.
4. Changing its relation with respect to temperature.

The texture of the soil, it has been seen, exercises an influence on its fertility, and on the modes of cultivating it. If clay too greatly predominate, the soil may be too adhesive and retentive

of water; if sand prevail, the soil may be too loose, the water too readily exhaled from it, and the matters of organic origin may be too imperfectly retained, and too quickly wasted. A just admixture of the two substances is to be sought for; but it is safer in most cases that there be a tendency to an excess of clay than of sand.

The texture of the soil, accordingly, may be improved by mixing clay with sand, or sand with clay. But the removing of large masses of earth is in all cases an expensive process; and it is rarely, therefore, that the farmer transports mere clay or sand from one part to mix with the clay or sand of another, with the sole design of improving the texture of the ground. He usually contemplates a chemical as well as a mechanical action; and, therefore, for the most part, he mixes together such substances as improve the constitution as well as the texture of the soil.

Thus marl, which is a mixture of clay and carbonate of lime, is frequently brought from a distance, or digged from beds beneath the surface, and mixed with the upper stratum of sand. By this means, not only is the mechanical texture of the soil improved, but the matters are added in which the sand is deficient, namely, alumina and lime. In the countries of the chalk, the marly matter of the lower beds is frequently digged up and mixed with the flinty chalk of the upper, and even brought from a distance for that purpose; by which means the upper chalk is not only improved in its texture, but in its constitution, by the addition of that aluminous matter in which it is itself deficient. In like manner, clay is often mixed with chalk, and chalk with clay. Clay and chalk are likewise mixed with peat. In the countries of the fens, it is common to dig up the clay on which peat rests, and mix it with the matter of the surface; by which means one of the greatest improvements of which peat is susceptible is at once effected, and a productive soil formed of one originally barren.

In these examples, the action is partly mechanical and partly chemical. In other cases, the mineral substances added to the soil are in too small a quantity to alter essentially or directly the texture of the soil, and chiefly act in promoting vegetation by

the addition of such matters as plants consume in growing, or by otherwise rendering the soil more fitted to perform its functions.

Vegetable and animal matters, in a decomposed or decomposing state, act in various ways in increasing the productive powers of the soil. They improve its texture, and they may be supposed to increase its power to absorb and retain moisture; but, above all, they supply that matter which, in whatever form conveyed to the organs of plants, tends to nourish them. This matter being absorbed by the roots of the plants, it must be supplied when exhausted.

Experience has in every age, accordingly, taught the husbandman to supply those substances to the soil; and the doing so forms one of the most important means at his command of maintaining or increasing its fertility.

It is seen, then, that the composition of soils may be improved by the addition of those mineral substances which may be required, or by supplying those animal and vegetable matters which afford nourishment to growing plants.

Another mean, analogous in its effects to the application of manures, of changing the texture and composition of soils, is incineration, commonly called Paring and Burning. This process will be described in connexion with the operations of tillage.

These, then, are the first of the means referred to of adding to the productive powers of soils, and will be considered in detail under the head, Manures, and other branches of the management of the farm.

The *second* mode referred to of increasing the productive powers of soils, is by altering their texture, depth, and properties, by mechanical means.

By the operation of the plough and other instruments, in preparing the ground for the reception of the seeds of plants, in tilling these plants when growing, and in removing weeds, the parts of the soil are divided, and the air is admitted into its interstices.

By continued pulverization of the soil, its parts are mechanically reduced to that state of division, which improves its texture

and increases the proportion of finely-divided matter. The air, too, which is thus permitted to act more freely on the parts of the soil, aids the mechanical processes in reducing the earthy particles to that finer state of division which favours the chemical actions which promote vegetation. Peaty turf, if suffered to remain in its original state, may continue to produce nothing but heath and useless plants; but, if frequently ploughed, and exposed to the influence of the atmosphere, it will tend to produce grasses of a better kind, and of greater variety. If, again, a subsoil of coarse clay be exposed to the atmosphere, it is at first unproductive; but by pulverization and exposure, its characters change. This is most remarkable in the case of clay-marl, a substance in itself containing the materials of a fertile soil, but which is often barren, until after pulverization and the influence of the atmosphere.

Another purpose sometimes promoted by tillage, and subservient to the amendment of the soil, is the deepening of the upper stratum.

The subsoil, it has been seen, is distinguished from the soil, properly so called, by the former containing less vegetable and animal matter, and so being less suited to the nourishment of plants; and in certain cases the subsoil is found to be injurious to vegetation. It is generally important, however, that there be a good depth of soil; and thus it is often expedient, for the effecting of a permanent improvement of the surface, to plough up and mix with it a portion of the subsoil, even though this subsoil should be in itself infertile. By exposure to the air, and comminution of its parts by tillage, the new material turned up loses by degrees its infertility, and the whole soil becomes amended, by a larger space being afforded for the extension of the roots of plants. This is matter of long experience in the garden, where deep trenching is practised for the purpose of forming or improving a garden soil.

The soluble matters of the soil are washed by the rains into the subsoil, and even heavier substances, as lime, sink into it. It is a point of good practice to bring up these substances again within

reach of the roots of plants, and hence deep ploughing is a mean of increasing the productiveness of a soil.

Often the subsoil is so hard as to resist the passage of water, and prevent the extension downwards of the roots of growing plants. Sometimes, especially in peaty soils, a large quantity of protoxide of iron collects, and, uniting with acid bodies, forms an impenetrable cement, provincially termed *moorband*. In this and other cases, the superincumbent soil is improved by breaking the hardened subsoil.

Frequently, in consequence of long-continued tillage, the subsoil becomes indurated immediately underneath the ordinary track of the plough, forming what is termed a *pan*. This pan resists the percolation of water, and interrupts the extension of the roots of plants, and it sometimes contains a sensible quantity of iron, derived from the metal of the tilling instruments. By deep ploughing, and breaking the hardened layer of the pan, the soil never fails to be improved.

These, then, are the principal mechanical means by which we can improve the soil, and they will be considered in detail, along with other methods of improvement, under the various heads which relate to the operations of tillage.

The *third* mode referred to of increasing the productive powers of soils, is changing their relation with respect to moisture.

In warmer countries, the soil is comparatively little injured by an excess of water, and more frequently suffers from the insufficiency of it. But in climates like ours, the operation of conveying away the water which is in excess, is an essential one, and, if neglected, any scheme of improvement may fail. The superfluous water is either stagnant upon the surface, or is derived from springs and other sources, and saturates the soil. The freeing of cultivated land from water upon the surface gives rise to the formation of land into ridges, by which the water escapes without stagnating upon the ground, or sinking into the subsoil. This is a matter necessarily connected with tillage, and will be described when the manner of cultivating land is treated of.

The freeing of the soil again from that superfluous water which

is derived from other sources, or which, from any cause, saturates the soil, forms a peculiar branch of agricultural improvement, and will be described under the head Draining.

As draining is more required in the colder countries, so Irrigation, or the watering of land, is less required there than in those countries where the heat and evaporation are greater. Irrigation, however, is a curious and interesting branch of rural economy, derived by us from very ancient times. In this country, it is chiefly employed for the watering of land in grass during the months of winter and spring, and will be described when treating of the Management of Grass-Land.

The *last* of the means referred to of increasing the productive powers of soils, is changing their relation with respect to temperature.

This mode of adding to the productive powers of soils, is less within our control than any of the others. It is only by slow degrees that we can improve the climate of a country. It is chiefly by draining, and by the rearing of hedges and wood, that it can be effected. These form important objects of rural economy, and will be partially treated of in this work.

The means, then, of adding to the productive powers of the soil,—namely, supplying to it the organic and earthy substances which may be required; altering its texture, depth, and properties, by mechanical means; and changing its relation with respect to moisture and temperature,—will all be treated of under the different divisions of our subject; and we shall begin with that which is most closely connected with the nature and properties of soils,—the nature and properties of those substances which we apply to the soil under the name of Manures.

II. MANURES.

All substances which, when added to the matter of the soil, render it more productive of plants, are in common language termed Manures.

Manures may be composed either of vegetable and animal bodies, or they may consist of earthy, saline, and other substances, derived from mineral matters. They may, therefore, be classed, according to their origin, into,

1. Vegetable and Animal Manures.
2. Mineral Manures.

To which may be added a mixed class, which, being derived partly from organic and partly from mineral substances, cannot be referred to either source.

All plants, it has been seen, and all the products of plants, are resolvable into carbon, oxygen, hydrogen, and, in smaller quantity, nitrogen or azote; and plants, and the products of plants, further contain certain earthy, alkaline, and other bodies in various states of combination, namely, silica, alumina, lime, magnesia, the oxides of iron and manganese, soda, potassa, common salt and other chlorides, sulphur, and phosphorus.

The soil, too, it has been seen, contains carbon and other substances derived from organic bodies, together with all the mineral matters of which the substance of plants consists.

In the practice of the farm, the seeds and other parts of plants are carried away, in whole or in part, from the ground which produces them, and thus the matters of organic origin, as well as the earthy, saline, and other mineral compounds, are taken from the soil, and, in certain cases, they must again be supplied, in order that the fertility of the soil may be maintained or increased. Vegetable substances consist of the matters which they had derived from the soil as well as from the atmosphere, and likewise of the earthy, saline, and other constituents, with which the earth had supplied them; and animal substances, being all directly or indi-

rectly derived from plants, contain likewise, in certain forms of combination, the ingredients, in whole or in part, of which plants themselves consist.

In supplying, therefore, animal and vegetable substances as manures to the soil, we, in truth, supply the same substances which enter into the composition of the living plants, and which they derive from the soil and the atmosphere. These substances, indeed, exist in the dead matter of the manures, in states of combination different from those in which they may exist in the living vegetable; yet still the same component parts are present, and must be believed to supply the matter of nutrition which the plants in growing require, although the new combinations which they form may be unknown, or the manner in which they are absorbed by the delicate organs of the plants may escape our observation.

That all the remains of organized bodies, whether vegetable or animal, nourish plants, is a truth which has been known and forced upon the attention of mankind from the earliest times. The discoveries of chemistry were not necessary to instruct men in a truth which so many natural phenomena presented to them. But the investigations of chemistry are not the less curious and important, that they accord with an observed truth, and shew that the same substances which exist in living bodies, exist in those which experience, from the earliest ages, had taught the husbandman to employ as the food of plants.

The application, likewise, of earthy, saline, and other bodies to the soil, as a mean of rendering it productive, has been practised from early times, and by the rudest husbandmen. All the substances of this kind hitherto employed, are found in plants, in different forms of combination; and when we add them to the soil, we supply the very matters which the plants require for their growth and development. But the substances of this class, besides affording matters which the living plants require, may act by rendering the matter of the soil itself better fitted to perform its functions. This class of substances therefore, though, equally with the others, to be regarded as manures, yet, exercising different actions, require to be separately treated of.

I. MINERAL MANURES.

The mineral substances which are employed as manures, may be supposed to exert two modes of action.

1. They may act upon the soil by producing new combinations, or by otherwise fitting the matter of the soil to promote the growth of plants.

2. They may act immediately on the plants themselves, by being carried by the sap into the organs of the growing plants.

And when received into the plants, they may either enter into their tissue, or combine with substances generated by the vegetable organs.

We cannot always distinguish when a mineral substance acts upon the plants through the medium of a change in the matters of the soil, or when it acts directly upon the plants, by being received into the vegetable substance, and much less can we determine what functions it performs in the vegetable organism. We can, however, draw conclusions, founded on experiment or analogy, as to the modes of action of the substances we employ. Such inquiries fall within the provinces of chemistry and vegetable physiology, rather than of agriculture; yet, if cautiously pursued, they may sometimes lead to a better knowledge of the conditions under which particular manures may be applied. I shall not, however, enter more into the theory of the action of these substances than the subject may seem to require.

The mineral substances which enter into the composition of plants and the soil, have been said to be silica, alumina, lime, magnesia, the oxides of iron and manganese, soda, potassa, common salt and other chlorides, sulphur, and phosphorus; to which may be added carbon, in so far as it is derived from the mineral kingdom.

Silica enters into the substance of plants, and largely, in combination with alkalies, into that of the stems of the cereal and other grasses. It is itself nearly insoluble in water; but, under

certain conditions, it is taken up by that fluid. Combining with the alkalies, it forms soluble salts, so that silica, in a state fitted to enter the roots of plants, is generally contained, in the quantity required, in the water of the soil. Silica, too, forming the greater part of all soils, it can rarely be necessary that we shall add it directly to the soil itself. The cases where this is sometimes done are when siliceous sand is mixed with stubborn clay, with peat, or with chalk; but silica, in such cases, is always mixed or combined with alumina and other matters. But silica, although rarely applied directly to the soil, is indirectly applied with the manures of the farm-yard, with wood-ashes, and with other substances, in which it exists in a state of mixture or combination.

Alumina exists in very minute quantity in plants, but forms an important constituent in soils. It is one of those mineral bases which combine with the matter of decomposed organic bodies, and with sulphuric, phosphoric, and other acids. It is rarely that we add alumina to the soil, except when it is mixed with calcareous matter. Mere clays, however, may be advantageously mixed with chalk, or with peat and sand; but, in these cases, it is always better that the clay contain a mixture of lime.

Alumina exists in the natural state in the well-known substance, Alum, which is a compound of the sulphates of alumina and potassa. Alum can be obtained at a moderate cost, and might probably be used with benefit as a manure; but sufficient experiments have not been made with it in its separate state.

Lime, in its several combinations, is the most useful of all the mineral bodies which have yet been employed as manures. It is found in the greater number of plants, in the bones and shelly covering of animals, in the waters of springs, rivers, and the ocean, and in almost all soils which are capable of cultivation. It exists in nature in various combinations, but most largely as a carbonate, in which state it forms vast mineral beds in every region of the globe. As employed in agriculture and the other arts, it is derived from all the following orders of rock-formations:—

1. From the rocks of the primary series, of which the limestones are exceedingly hard and crystalline, affording a pure lime, and the finest of our statuary marbles.

2. From the transition rocks, the limestones of which, like the last, are very compact and crystalline, and yield a lime of good quality.

3. From the mountain limestone and calcareous deposites of the coal formation, from which sources the largest supplies are derived in this country, because, along with the limestone, exists the fuel for calcining it.

4. From the magnesian limestone; which, from its being largely mixed with carbonate of magnesia, possesses peculiar properties, to be afterwards referred to.

5. From the lias and oolite formations; which, however, generally yield a lime much mixed with other earths.

6. From the chalk, from which lime in unlimited quantity can be obtained; but from the fuel being distant, the expense of calcination is frequently considerable.

7. From the tertiary deposites; from which, however, little lime is obtained in England. In other countries, however, as Italy, the limestones of the tertiary series are largely used for building, and for yielding lime for mortar.

Carbonate of lime, when subjected to a red heat, loses the carbonic acid with which it was combined. It then becomes lime, which is a substance of an earthy nature, of alkaline or caustic properties, and capable of exercising a powerful action on animal and vegetable substances.

In order to obtain lime from the carbonate, the limestone is calcined in heaps intermixed with fuel, or better in a large kind of furnaces, termed lime-kilns. The limestone and fuel are put into the lime-kiln and ignited; and after a time, when the fuel is consumed, the raw material, deprived of its carbonic acid, is removed. But it is better that the lime-kiln be so constructed, that the lime shall be withdrawn from apertures below in proportion as it is calcined, fresh limestone and fuel being added from

above, so that, the contents of the furnace being once ignited, the process of calcination may proceed without interruption.

The lime thus obtained is very impure, being mixed with the other earthy matter of the limestone, and the residue of the fuel; but it is perfectly adapted to the valuable purposes of the arts to which it is destined. It has lost above 40 per cent. of its weight, and hence the economy of carriage by calcining limestone in the places where it is obtained.

Lime, as it is derived from the kiln, is never spread upon the ground in the practice of the farm. It is first allowed to combine with water, in which case it swells out to about twice its former volume, and crumbles down, forming a fine powder. In this state it is a hydrate of lime, and termed Quicklime by farmers.

It is this action of the combination of lime with water which forms the process of slacking, or loosening, so well known as the means of preparing lime for its uses. When the calcined material is exposed to the air of the atmosphere, it attracts moisture, and slowly crumbles down; or if water be added in quantity, the lime combines at once with it, and quickly falls into powder. The water, in becoming solid, gives out its latent heat, which is often sufficient to kindle inflammable bodies. About 28 parts by weight of lime combine with 9 of water, so that newly calcined limestone increases about one-third in weight by being slacked. The compound produced retains the caustic properties of the original lime: it is soluble in water, and, when pure, is perfectly white.

Lime, besides its attraction for water, has a strong affinity for carbonic acid. When lime, therefore, after being slacked, is exposed to the air, it begins to attract carbonic acid from the surrounding medium. The carbonic acid gradually takes the place of the water, and the hydrate becomes a carbonate. Thus the lime recovers the principle which it had lost by calcination; and becomes again a carbonate, without, however, recovering its former external characters. In proportion as it combines again with carbonic acid, it loses the properties which it had acquired by calcination. It ceases to be caustic, and becomes insoluble in pure water.

It is chiefly this property of combining again with carbonic acid, which renders lime useful beyond all other substances as a cement in building. The hydrate, that is, the lime after being slacked, when formed into a paste with water, attracts carbonic acid, and becomes cohesive and hard. If it be mixed with silica and alumina, the mass becomes more coherent than when lime alone is employed. Hence, in preparing common mortar, the lime, after being fully slacked, is mixed with sand, and formed into a paste. During these processes, and after being applied to the wall, the mortar attracts carbonic acid, and is ultimately converted wholly or partially into a carbonate.

In the practice of the farm, the calcined limestone, or quicklime, is usually laid in the field in heaps, where it is suffered to slack by means of the rains and moisture of the air; and sometimes water is applied to hasten the process. When fully slacked, it is applied to the ground in the manner to be hereafter described. But sometimes it remains so long in the heaps, that it not only slacks, but attracts carbonic acid in such quantity as to be again partially converted into a carbonate.

Lime, however, in its state of hydrate, is more perfectly divided, and may be spread more equally upon the surface, and better mingled with the soil, than when it has again become a carbonate. It is then likewise soluble in water, so that the rains quickly bring it in contact with every particle of the soil. Further, in its state of hydrate, it produces effects which it either does not produce in its state of carbonate, or which it produces more slowly, or in a less degree. It is therefore a point of good practice to apply lime as soon as possible after it is slacked, and while it still retains its solubility and caustic properties.

When lime has been mixed with the earth, it soon attracts carbonic acid from the matters of the soil, and becomes mild. In this state, it is fitted to enter the roots of growing plants. It is indeed in itself little soluble in water, but water, when it is charged with carbonic acid, which it generally is in the soil in a greater or less degree, has the property of dissolving the carbonate in small

quantity; and besides, it is probable that the fibrils of roots, in coming in contact with the carbonate, render it soluble, and capable of being absorbed.

Lime exercises a powerful action in decomposing the ligneous parts of plants, attracting their carbon and oxygen, and producing new combinations. Thus, if applied to peat, it is observed to decompose very quickly the vegetable fibre, reducing the whole to a mass resembling dark vegetable mould.

Lime, too, performs the part of a base, and combines with matters formed by the decomposition of animal and vegetable substances in the soil, forming compounds which are themselves often insoluble, or little soluble, in water. But these compounds, exposed to the continual action of water and air, are altered after a time, and furnish new compounds, capable, it must be believed, of nourishing plants. Lime, therefore, by forming these compounds, prolongs the nutritive action of animal and vegetable substances beyond the period during which they would have acted, had they not entered into combination with lime.

Of this mode of action of lime, an example may be given in one of the arts. When it is wished to carry off, from the vegetable juices in the manufacture of the sugar of beet, the animal substances which have been used for purifying them, lime is employed, which combines with these substances, and rises with them to the surface in the form of a thick scum, which is insoluble in water. This scum, under the older processes of the manufacture, when laid upon the fields, had no beneficial action on plants so long as it remained insoluble, but after being deposited for a sufficient period in a trench, and permitted to ferment, it formed a rich manure.

Thus, too, when lime is applied to a rich garden soil, it is frequently observed to produce a temporary sterility; which may be ascribed to the lime combining with the animal and vegetable matters in the soil, and producing insoluble compounds.

In like manner, when lime is mixed with any pure animal substances, it forms with them less soluble compounds, and renders

their effects on the soil less sudden, but more permanent. Thus, being mixed with night-soil and other fæcal matters, a manure is produced which is capable of preservation.

Lime, in performing the part of a base, combines with certain acids which are formed in the soil by an excess of water. Land which has been saturated with water is said by farmers to be soured; and the expression expressly denotes the effect, for acids are really formed, which retard the decomposition of vegetable substances. The application of lime neutralizes acids of this kind, and, in the language of farmers, *sweetens* the soil.

Lime sometimes forms new compounds with mineral matters existing in the soil. Thus, if sulphate of iron, or green vitriol, which is a compound of sulphuric acid and protoxide of iron, exist in the soil, and lime be applied, the lime may combine with the sulphuric acid, and form a sulphate, and thus convert into fertilizing matter a substance which in excess is injurious.

Hence we see the beneficial effects which generally result from applying lime to a subsoil, which is exposed for the first time to the air. Such subsoils frequently contain sulphate of iron, as well as other metallic salts, which exercise an injurious influence on plants. Whenever it is wished to deepen a soil by ploughing up a portion of the subsoil, the readiest means which we possess of counteracting the hurtful effects of the newly exposed material is an abundant application of lime.

Lime is found to increase the productiveness of plants cultivated for the farina of their seeds, and in an especial degree of the cereal grains, and to cause them to ripen more early. It is likewise eminently favourable to the growth of leguminous herbage and forage plants, such as lucerne, sainfoin, and the clovers, and likewise of the common grasses. When lime is spread upon a piece of peaty turf, it is frequently found to eradicate, in whole or in part, the mosses, lichens, and heaths, and to permit the native grasses and clovers to grow.

Lime, when added to a piece of land, renders a smaller application afterwards necessary of putrescent manures. Hence, lime

may be regarded as an important mean of economizing such manures in parts of the country distant from the sources of supply.

To admit of the beneficial action of lime, the soil should be freed from superfluous water. Lime, it has been said, neutralizes certain acids which are produced by the action of stagnant water; but if, after one portion of these acids has been saturated, other portions are suffered to be formed, the evil will remain as if the lime had not been applied. Not lime only, but all manures, are less efficient, when the land is saturated by water; and hence the use of draining as a mean of increasing the efficiency of manures.

Lime may be applied to the land in different ways, and at different periods.

1. It may be laid on the surface of land which is in grass, and remain there until the land is ploughed up for tillage, even though this should be several years afterwards. The lime, in this case, quickly sinks into the soil, and, acting upon it, prepares it for crops when it is again tilled.

2. It may be spread upon the ground, and covered by the plough, just after a crop of any kind has been reaped. In this case, it prepares the soil for the succeeding crops.

3. It may be spread upon the surface, even when plants are growing. This practice, however, though sometimes convenient, is rarely to be imitated.

4. It may be, and most frequently is, applied during the season in which the land is in summer-fallow, or in preparation for what are termed fallow-crops.

5. It may be mixed with earthy matter, particularly with that containing vegetable and animal remains; in which case it forms a compost.

The quantity of lime applied to soils is very various, and is dependent upon the nature of the soils, the climate, and other circumstances.

The stiff clays for the most part require a larger proportion of lime than the lighter soils; and in the case of such soils as con-

tain much undecomposed vegetable matter, as peat, a quantity should be applied sufficient to decompose effectually the inert fibre.

In the north of England and south of Scotland, a moderate application of lime for the lighter soils is held to be 120 bushels, heaped measure, of unslacked lime, and a medium dose for soils of different kinds, about 130 bushels, though a much larger quantity than this is applied in certain clay-land districts.

The periods at which doses of lime should be repeated differ according to the quantity applied and the manner of using it. In cases where the large applications just spoken of are made, an effectual liming need not usually occur in less than fourteen or fifteen years.

But in other cases, lime is applied in smaller quantity, and more frequently, and there is nothing opposed to a sound theory in this practice. Nay, there is reason to infer that a more frequent application of lime, and in smaller quantity, is the most economical method of using it, after land has been brought into regular culture.

The application of lime calls into powerful action the nutrient principles of the soil; and hence, if land be severely cropped after lime has been used, it is reduced to a greater state of sterility than if the mineral had not been applied. Lime, therefore, calculated as it is to produce the best effects in fertilizing a soil, is frequently made the means, in the hands of an injudicious farmer, of injuring it. This is especially observable in the case of light soils of an inferior kind. These are frequently so injured by injudicious cropping after the application of lime, that they are reduced to a state of the greatest barrenness. When soils are brought to this condition by scourging crops, they cannot be restored to fertility by a subsequent application of lime. So far from this, the future dose generally renders them more barren than before. The only good remedies are the application of vegetable and animal manures, and rest in grass.

But although the active properties of lime may be abused, it is an instrument of production of the highest importance in the hands

of the skilful farmer. On land improved and cultivated for the first time, it exercises a powerful and lasting influence. For the reclaiming of peaty and moory soils, it is the most efficient agent which has yet been discovered. In North Britain, where this class of soils prevails, all the most essential improvement of land previously waste has been effected by the free use of lime; and in Ireland, it has been employed with the best effects on the peaty soils which so largely exist in that country.

But in proportion as land becomes rich by regular culture, and the continued accretion of extraneous matters to the soil, the comparative value and necessity of liming diminish. In the neighbourhood of cities, lime is little used, because the refuse matter of the town contains more or less of lime, and because a sufficient quantity of soluble putrescent matter already exists in the soil, or can be obtained from the adjacent towns.

The farmer has generally a sufficient indication of the want of lime in his soil by the less vigorous vegetation of the grasses and clovers, by the growth of sorrels, and by the prevalence of mosses and other cryptogamic plants.

Lime, in the state of hydrate, exercises a more powerful action on the matters of the soil than when in the state of carbonate; yet carbonate of lime performs important functions, and exists in nature in several states in which it is beneficially employed as a manure.

Marl is a mixture of carbonate of lime with clay, or with clay and sand, and it may contain sulphates and other compounds. It occurs in beds, and is extensively diffused through all the secondary formations, assuming a great diversity of appearance, according as it is more or less compact, or as the lime, clay, or sand, prevails. When very indurated, it is frequently termed rock-marl, and is generally held to be valuable in proportion to the quantity of calcareous matter which it contains.

Marls should be laid upon the surface, and generally well exposed to the action of the air, before being mixed with the soil; for certain marls are found to be deleterious unless they shall have undergone this previous exposure. The kinds of soil to which

marls are most advantageously applied are the lighter kinds,—the sandy, gravelly, and peaty, and the flinty chalks.

The quantity of this substance employed is exceedingly various, being dependent on the nature of the soil, and the proportion of calcareous matter in the marl. When the purpose has been to change entirely the constitution of a defective soil, marl has been applied at the rate of from 300 to 400, nay of from 500 to 600, cubic yards to the acre. But when it is merely intended as a periodical manuring, it is applied in the quantity sufficient to afford an ordinary proportion of calcareous matter, as at the rate of from 80 to 100 cubic yards. Being spread upon the surface of the ground when in grass or stubble, it is allowed to remain there until the ordinary period arrives for ploughing the land.

Marl is much more slow in its operation than quicklime, but more enduring in its effects. It was extensively employed in the early husbandry of the British Islands; but it has given place, in many cases, to the more active agent, quicklime. It has been employed with peculiar success in the improvement of loose sandy soils, to which it communicates not only calcareous matter, but the clay of which the sand stands in need. The county of Norfolk owes much of its acquired fertility to the large use of marl; and in parts of Belgium, the greatest improvement which sandy soils have received in Europe has been effected by means of this substance.

Shell-marl is another form in which carbonate of lime is applied to the soil. The substance so termed is a deposite of the shelly covering of land mollusca, and is frequently found under beds of peat. It is more or less mixed with earths, and contains an appreciable quantity of gelatinous animal matter. It may be used at the rate of from 25 to 30 cubic yards or more to the acre. It can be applied when the land is in various states, as when it is in stubble, in summer-fallow, or in grass. In the case of land in grass, the calcareous matter improves the growing herbage-plants, and, sinking into the soil, prepares the ground well for producing crops of corn, when it is broken up for tillage.

The same consequence is produced by excessive cropping after the application of this substance as after that of calcined limestone. The soil which has been stimulated by the action of the mineral becomes more barren than before, and its productiveness is only to be restored by rest and the action of animal and vegetable manures.

Carbonate of lime is sometimes applied in the form of sand, consisting of siliceous matter mixed with broken corallines and shells. Calcareous sand is frequently found in quantity on the western shores of these islands. It is found in Cornwall, where it is carried considerable distances inland, in the west of Ireland, in the Hebrides, and in the numerous creeks of the coast of Argyleshire. It may be spread at any time on the surface of land in grass, the herbage of which never fails to be improved by the application.

In Ireland, large quantities of indurated marl, which is there termed limestone gravel, is applied to the soil ; and in some parts of England, a kind of gravel formed by the disintegration of certain limestones, is used with advantage.

Carbonate of lime is likewise applied to the soil in the state of chalk. The chalk employed for this purpose is that of the lower beds, which is more or less mixed with clay. An ordinary chalking is from 150 to 200 bushels to the acre, but sometimes much beyond this quantity is applied. It improves the earthy soils, as well as the flinty chalk.

Lime is likewise applied to land in other combinations, of which the most important are the Sulphate and Phosphate.

Sulphate of lime, or Gypsum, is a compound of sulphuric acid and lime, and usually contains a definite quantity of water. It is found in almost all the rock-formations above the primary, to the tertiary, and most largely in the new red sandstone and countries of the chalk. It exists in many springs, communicating to the water the property termed hardness : it is found in the greater part of cultivated soils, in the manures of the farm-yard, and in the ashes and other refuse matter of towns. It exists in most species of plants, and largely in lucerne, sainfoin, clovers, and other

leguminosæ. Although little soluble in water, the roots of plants have the property of taking it up very quickly, so that certain soils are soon exhausted of their gypsum, and the plants to which it is necessary, either cease to grow, or grow feebly;—and then the salt must be again supplied, either by adding gypsum, or indirectly by the means of manures in which it is contained.

Gypsum, when exposed to a gentle heat, parts with its water, and is easily reduced to a fine powder, in which state it is applied to the soil, or it may be used in the raw state, and pounded, without having undergone calcination. It is scattered on the growing plants, usually in the latter part of April or in May, when the leaves are well developed, and the time to be selected for sowing it is when the plants are moist with rain or dew. It is employed at the rate of from 2½ to 3 cwt. to the acre. When the plants are those which take it up in quantity, it may be repeated almost every season. It is especially suited to lucerne, sainfoin, and the clovers, and being little costly, on account of the small quantity employed, it is often a valuable manure, especially in the case of the artificial meadow.

Gypsum is more highly esteemed, and more largely employed, in some other countries than in England, as in France, parts of Germany, and the United States of America. This may be supposed to be, either because the soils of England contain naturally more of this salt, or because it is supplied to the soil in larger quantity by the manures of the farms and the towns. The want of gypsum is shewn when the cultivated clovers cease to grow with vigour, and when the soil, to use the common expression, becomes *tired* of the crop.

Gypsum is found in quantity in the ashes of various peats, and some of these accordingly are used with extraordinary benefit in the manuring of the cultivated clovers and artificial meadows.

Phosphates of lime are found in the grasses and other plants which form the food of herbivorous animals, and largely in the seeds of the cereal grains.

Phosphates are therefore applied to the soil, in most manures derived from plants and the fæces of animals. Latterly, the bones

of animals themselves, which consist in great part of a peculiar phosphate of lime, have been largely employed as manure, and will be treated of in the sequel under the class of manures of animal origin. A peculiar phosphate of lime exists likewise in the mineral state; but it is found only in quantity in a few places, and has not yet been employed as a manure, except for experiment on the small scale. It is found in Bohemia, and in the kingdom of Estremadura in Spain, and in some other places. It is a variety of the mineral termed Apatite, and it is probable that it might be substituted in part for the earth of bones, although wanting the animal matter which these contain.

Lime combines with nitric acid, and forms nitrate of lime. This salt is produced in certain composts, to be hereafter referred to, and is formed in many cases in the soil itself by the action of lime and decomposing organic matters; but it is not found in mineral deposites, and has not yet been prepared artificially in quantities to render it largely applicable as a manure. Its composition leads us to infer that it would be a powerful fertilizing agent; bnt it is a very soluble salt, and is therefore readily washed into the subsoil, or carried away by rains.

Magnesia resembles lime in its general properties, and, like it, existing in plants and the soil, it may be believed to serve important ends in the economy of vegetation.

Magnesia is found in many limestones, and when these are calcined, it is applied to the soil along with the lime. It is found in most of the limestones of the coal-formation; and in those termed Magnesian it exists in large quantity.

The magnesian limestone formation of England, it has been stated, forms a narrow tract from South Shields to Nottingham. It is used for the purposes of building and agriculture. It is found, however, that if applied, after being calcined, in the same quantity as other lime, it produces a temporary sterility, burning, as it were, the soil; hence it is termed *hot-lime*, and is applied in much smaller quantity than other kinds of lime. The effect has been thus explained: Magnesia has a smaller affinity for carbonic acid than lime, and when both are calcined together, and applied

to the soil, the lime attracts carbonic acid, and the magnesia remains longer in the caustic state. From the result it is inferred, that in this condition it produces the burning action referred to. When arrived at the state of carbonate, magnesia seems to exercise a highly favourable action; and magnesian limestone may perhaps be regarded as the most valuable of any, since a smaller quantity of it suffices for the ends proposed. No other limestone is so efficient in the case of peaty soils; and it is probable that the superiority observed in the case of the limestone of the coal-formation over that of the pure chalk is due to the presence of this earth.

Magnesia, like lime, combines with sulphuric, nitric, and phosphoric acids.

Sulphate of magnesia forms the compound, Epsom salt. It is found in certain mineral springs, and largely in many soils; but it does not, like the sulphate of lime, form deposites from which it may be obtained in quantity. It may, however, be formed artificially at a low price. It might be employed in the same manner as gypsum, and might be found of equal benefit in the case of the cereal grains, in the seeds of which it exists, as the sulphate of lime is in the case of leguminous plants. Being a product of plants, it is necessarily applied in the vegetable and animal manures of the farm.

Nitrate of magnesia, like nitrate of lime, is a very soluble salt. It may be supposed to be formed in soils and composts in which magnesia is present; but it has not been applied to the soil as a manure, nor is it likely, from the expense of obtaining it, to be so employed.

Phosphate of magnesia, like phosphate of lime, exists in plants, and is supplied from the same sources, namely, the animal and vegetable manures of the farm. It is found in urine, and in the earth of bones, in which it exists in a considerable proportion, along with phosphate of lime.

Iron, although it exists in plants, and largely in the soil, has not, in any of its forms, been employed as a manure. This, we may believe, is because we are not sufficiently acquainted with the con-

ditions under which it may be applied; for iron existing in plants and in the soil, it cannot be doubted that it performs important functions in the economy of vegetation. Even green vitriol, when used in small quantities, has been found to be fertilizing; and plants have been found to vegetate and grow luxuriantly in soils mixed with more than half their weight of peroxide of iron.

Manganese, like iron, exists in plants and soils, although in minute quantity; but it has not been employed in any of its combinations as a manure.

Potassa and Soda are largely found in plants and soils; and no productive soil is known to us in which they do not exist in some of their combinations.

Potassa is obtained, for the purposes of the arts, by burning plants, and washing their ashes. The substance thus obtained is the carbonate, mixed with silica and other substances. It is the common potash of commerce, which, by further purification, becomes pearl-ash, so largely used in the arts. From this substance potassa can be readily obtained in combination with water, forming a hydrate. This is a powerfully caustic body, quickly decomposing all animal and vegetable substances with which it comes in contact. It has a great affinity for carbonic acid, with which it quickly combines, destroying the organic tissues with which it is in contact, in order that it may obtain it.

Carbonate of potassa is not applied to the soil in its separate state, but it is applied in the manures of the farm, and especially in the ashes of trees, shrubs, herbaceous plants, turf, and peat. Ashes of all plants, when applied to the soil, produce a rapid vegetation. They contain, indeed, besides carbonate of potassa, sulphate of the same base, and various salts which must contribute to their fertilizing properties; but the carbonate of potassa is doubtless an element in their action. Analogy leads us to the conclusion that, if carbonate of potassa were applied in the separate state, it would be a very potent manure.

Potassa combines with sulphuric and nitric acids. The Sulphate has not been employed in its separate state as a manure, except on the small scale, for the purposes of experiment; but it

exists in plants, and is, therefore, supplied in the manures of the farm-yard.

Nitrate of potassa, or Saltpetre, is naturally formed in the richer soils, by the formation of nitric acid, which combines with the alkaline base, in the same manner as nitrate of lime is formed in compost heaps and soils. Saltpetre is sometimes applied to soils in the separate state. It is in this case finely pounded, and scattered on the growing plants at the rate of from 1 to $1\frac{1}{2}$ cwt. to the acre; and the period for using it is in spring, when the plants are yet young, but the leaves sufficiently expanded. It produces a development and verdure of the leaves which endure throughout the season. When applied to potatoes, it produces a great growth of the stems, and often of the tubers; but in the case of the cereal grains, although it causes a vigorous growth of the straw and leaves, it does not appear to produce any increase in the quantity or quality of the grain. It produces a great growth in pease and beans, and adds to the luxuriance of the common herbage-plants. Its effects appear to be transient, being little perceptible beyond the season in which it is used. It has generally little efficacy in the case of rich soils artificially charged with the remains of organic matter; but in deep peaty soils, it is the most active manure that can be used, causing a rapid growth in the coarser grasses and rushes proper to such soils. It is sometimes used in the refuse of the gunpowder manufactory, and nearly the same rapid but transient action is observed as when it is employed alone.

Soda is obtained in the state of carbonate by the incineration of certain plants which grow in saline soils and the margins of the ocean, and largely by the incineration of fuci and other algæ which grow on submarine rocks. The ashes of this latter class of plants afford a very valuable manure, which will be referred to in treating of those of vegetable origin. Their effects are due to other substances, as well as the carbonate of soda, but this, doubtless, exercises its proper action. A carbonate of soda, termed Natron, is found abundantly in the mineral state in Egypt and elsewhere, and other forms of the carbonate exist in other countries; but it is not known that these substances have been used as manures.

Carbonate of soda is now obtained, by chemical means, from common salt, and might be furnished at a moderate cost.

Soda, combined with sulphuric acid, forms Glauber's salt, which can be prepared artificially at a reasonable price. Sulphate of soda existing in most soils, and in the ashes of plants, analogy leads us to the conclusion that it may be used as a manure. In the case of potatoes—a plant which seems to admit of the powerful action of this class of substances—this salt has been found to act with great effect in increasing the production of the stems and leaves.

Nitrate of soda has been found in the mineral state in South America, in a district near the northern frontier of Chili, extending in beds over a tract of country nearly forty leagues in length. From this prodigious deposite it has been brought to Europe, chiefly as a substitute for saltpetre in the manufacture of nitric acid, and in this manner has been introduced into agriculture. The effects of this substance are nearly the same as saltpetre. It exercises a powerful but transient action. Being finely powdered, it is strewed upon the surface of the growing plants in spring, when the leaves are slightly moist. It is used at the rate of from 1 to 1½ cwt. to the acre, and this slight application produces a rich growth in the stems and leaves. The action, however, being almost limited to a single season, this substance is now regarded with less favour than at its first introduction.

The other substances mentioned as being found in plants, are sulphur, phosphorus, and chlorine.

Sulphur has not been applied in this country as a manure, although it would supply an ingredient existing in plants and the soil. Phosphorus is only employed indirectly as a phosphate, in the case of certain animal manures.

The Chlorides are combinations of chlorine with other bodies. Two only need be referred to—the Chlorides of Calcium and Sodium.

The earth lime is composed of oxygen and a metallic body, calcium; and chlorine combining with the latter, forms chloride of calcium. This substance appears to be produced in certain cases

in the soil and in compost heaps. A mixed substance, usually called chloride of lime, is now largely employed in the arts, as a bleaching-powder; and it has been found by experience that the refuse matter of bleaching-works has a considerable effect when spread upon the ground.

Chloride of sodium is a compound of chlorine, with the metallic base of soda, and forms the well-known substance, Common Salt. In every period of the history of agriculture, disputes have arisen regarding the value and uses of salt as a manure. By the ancients, a salt soil was regarded as synonymous with an unfruitful one; and the margins of the ocean, and vast saline deserts, attest the noxious properties of this substance when in excess. Yet salt is found over all the lands and waters of the globe, and enters universally into the composition of plants and animals, and is probably as essential to their health, and even existence, as other substances which enter into their tissues and food. When salt is applied in quantity to living plants, it destroys them; yet, when applied in small quantity, it has been found, in many cases, to promote their growth. In certain cases, when mixed with the matter of the soil, it has been found to be useless or noxious, while in others it has certainly increased its fertility in a high degree. These discordant results have led to the differences of opinion which have always existed, and which yet exist, with respect to the uses of salt as a manure.

Salt, existing in all plants and the excrements of animals, is applied to the soil in all the common manures of the farm-yard and the towns. When putrescent manures are applied periodically, and in quantity to the soil, salt is generally furnished in the quantity required for the uses of the growing plants, and any excess may be useless or even hurtful. It is even supplied by rain-water, which frequently contains an appreciable quantity of it. Hence so many experiments with salt have been found unprofitable; and hence, also, the error of supplying this substance to a soil, unless we have learned from previous experience that it will produce a good effect.

When salt is applied to growing plants, it should be in small

quantity, not exceeding a few bushels to the acre. The plants to which it may be most safely applied are the common herbage-grasses. These perhaps will not grow with greater luxuriance; but the application of the salt will render them more grateful to animals, which will be observed to feed eagerly on the parts on which salt has been spread.

But the most advantageous manner of applying salt is by mixing it with the manures to be used. If mixed in a compost heap with lime, earth, and other substances, it increases, in a perceptible degree, the fertilizing properties of the material. In the parts of England where rock-salt is found, the farmers mix it largely with the dung of the farm-yards, and the materials of their compost heaps.

Salt has the property of destroying growing plants; and hence, if laid on land in considerable quantity, it will contribute essentially to the destruction of weeds. With this design it has been sometimes applied, in the early part of spring, to land in summer-fallow, at the rate of 20 bushels or more to the acre.

Of the mineral manures enumerated, lime is that which, from its abundance in the natural state, is the most generally employed, and which, from the permanence of its effects, is the most important as an agent for improving the soil. But the alkalies and their compounds, from their more powerful and immediate action, are likely to be more largely used than hitherto for promoting the growth of particular crops; and the use of them may be expected to extend in proportion as further experience shall shew the conditions under which they may be safely or beneficially employed. The farmers of this country have been gradually conducted to the freer use of these more powerful applications, by the multiplied facilities of obtaining them, in consequence of the cheaper production, and the increasing refuse of innumerable manufactories. They may be expected to add materially to the resources of agriculture. But as the alkalies form more soluble salts than lime, their effects are more transient, and greater caution is required in using them; for as injury is known to result from severe cropping after lime, so greater injury may be expected, under similar

treatment, to follow the application of substances which produce a stronger action on the decomposable matters of the soil.

As plants require not one substance, but many, to promote their growth, mixtures of different salts employed in small quantities may be expected to be more useful than a single one. This has given rise to the idea of forming fertilizers, as they have been called—that is, mixtures of different salts to be applied to the soil; and manufactories have been even formed for supplying this class of substances. But farmers who may be desirous to make use of mixtures of this kind, will generally do better to procure the salts and mix them on the spot, applying them either directly to the soil, or through the medium of the compost heaps of the farm, in such proportions and in such quantities as experience shall shew to be beneficial.

II. VEGETABLE AND ANIMAL MANURES.

All plants, it has been said, derive their mineral ingredients from the soil, and their carbon and other constituents partly from the soil and partly from the air of the atmosphere. Were all the seeds, leaves, and other parts of plants, to be mixed again with the matter of the soil, the latter would continually increase in fertility. But a large part of these substances is carried away from the ground which produces them, either directly, or through the medium of the animals to which they furnish food. But animals, in leaving their excrements upon the farm, return in great part the substances which they had derived from the earth, and the application to the soil again of these substances, and of the vegetable matters employed as litter or otherwise, is the most important of the means possessed by the farmer of maintaining or increasing the fertility of his land.

That the vegetable and animal substances applied to the soil may perform their functions, they must undergo decomposition; and of the means which nature employs for this end, one is the

putrefactive fermentation, by which the parts of organized bodies, when life is extinct, are dissolved, dispersed, or formed into new combinations.

All animal and many vegetable substances, under the necessary conditions, tend to undergo the putrefactive fermentation. In the case of manures, the fermentative process may either take place before the matter of the manure is mixed with the soil, or after it is mixed with it. In practice, it is common to cause the manure to be partly fermented before it is applied to the soil, and then to allow the final decomposition to take place in the soil itself.

All animal matters decompose when acted upon by moisture and the air, the greater part of their constituents making its escape in various forms of gaseous combination. The results of the putrefaction of animal bodies are, ammonia, sulphuretted and carburetted hydrogen, and other compounds.

When this decomposition takes place beneath the surface of the ground, these gaseous compounds may be supposed to be partially or wholly retained in the soil. Purely animal substances, therefore, which thus readily decompose, do not absolutely require fermentation before they are mixed with the soil. Yet, even in the case of purely animal substances, advantages may result from subjecting them to a certain degree of previous fermentation, of which one is, that, being mixed with vegetable matter, they promote the more speedy decomposition of vegetable fibre.

Vegetable fibre is, under certain circumstances, a slowly decomposing substance. When vegetables are green and full of juices, they readily undergo decomposition; but when they are dried, as in the case of straw and other litter, they decompose with slowness, and the mixing of them with animal matter hastens the putrefactive fermentation. This mixing together of animal and vegetable substances is the process employed for preparing the dung of the farm-yard, which affords the chief supplies of putrescent matters on the farms of this country. The dung of the farm-yard will be treated of in the sequel, attention being, in the first place, directed to those various vegetable and animal

substances which may be applied to the soil in their separate state, and which are either produced upon the farm, or derived from other sources.

Herbaceous plants, when soft and full of juices, quickly undergo decomposition when mixed with the matter of the soil. A practice derived from early times, and still pursued in many countries, is to raise such plants on the ground to which they are to be applied, and when they are yet green and soft, to plough them down, and thus mix them with the earth. In this state they very soon pass through their changes of decomposition, and afford an enriching manure to the subsequent crop.

The plants the best suited for this purpose are those which grow quickly, and evolve a large system of leaves. The Greeks and Romans, who were familiar with this practice, and who have bequeathed to us many careful precepts regarding the kinds of plants to be employed, and the periods of covering them, made use chiefly of the bean and the lupine, but in an especial degree of the white lupine; and this plant, on account of its easy culture and rapid growth, is still that which is preferred by the inhabitants of Tuscany and other parts of Italy where this ancient practice is pursued. But other plants, even the cereal grasses, are likewise employed in these countries of quick vegetation. In the more northerly parts of Europe, the broad-leaved clover is sometimes ploughed down, chiefly the second or third crop of the season. Borage and corn-spurry are sometimes used in Germany and Holland, the latter plant, because it can be raised on barren soils. But of the plants employed in these latitudes, the most common are Buckwheat and Rape.

Buckwheat may be cultivated late in summer, and soon arrives at the required maturity: hence, in England, it is sometimes practicable to grow it on land prepared for summer fallow, and to cover it before the subsequent crop is sown. The most suitable period for ploughing it down is when it has come into flower, but before the seeds have begun to be formed, and the stems to become ligneous and hard. But rape, and, indeed, various other

plants, which may be sown after harvest, in time to put forth a considerable system of leaves before winter, may be found preferable to buckwheat.

This simple species of manuring is cheap, and therefore, in certain cases, may be adopted. It is, however, better suited to the warmer countries, where vegetation is rapid, than to the colder. In England, the practice has made little progress ; because, when green food of any kind is raised, it is found to be more advantageous to apply it to the feeding of the animals of the farm, in which case it not only yields manure but affords food.

A manure of the same class consists of the Roots of plants disengaged from the ground in the process of tilling and cleaning it. But the plants of this kind have usually vivacious roots and underground stems, and it is therefore necessary to destroy their vegetative powers before they shall be again mixed with the soil. This may be done by forming them into compost heaps, along with quicklime, salt, or any substance which may destroy them ; but many farmers, on account of the convenience of clearing their land at once of these troublesome plants, burn them in little heaps upon the ground at the time of their being collected, and spread the ashes upon the surface. The more careful husbandry is to collect and form them into composts.

The Leaves of trees form the natural manure of forests, and, under certain conditions of temperature and moisture, accumulate, and form a bed of vegetable soil. But leaves not being collected until they have fallen from the tree, their juices have been exhaled, and what remains is chiefly dry ligneous fibre, with the earthy and alkaline substances contained in the leaf. They are collected by gardeners, chiefly for forming beds beneath the soil for certain vegetables cultivated under glass. They are rarely obtained in this country in such quantity as to be employed as manure for the farm. Where the means, however, exist of obtaining them, they should be collected before winter, and mixed with the dung of the farm-yard, or other refuse of the homestead.

Under the class of soft vegetable manures, is one of great value in the places where it can be obtained, consisting of the various kinds of sea-plants which grow on maritime rocks.

Sea-weeds, as they are termed, consist of numerous species of fucus and other algæ. They are either cut from the rocks on which they grow, or cast ashore by the waves, especially after high tides and storms. They abound in a glutinous substance, which is very soluble, and which, when they are laid on the surface, is washed into the soil by the rains. The most common and convenient method of employing them is to convey them directly to the land as they are cast ashore, and to apply them fresh as a top-dressing to the grass-land or growing crops of any kind. But it is manifestly better, when circumstances allow, that they be covered by the soil when they are in the fresh state. When this is not practicable or convenient, they may be formed into a compost with dung.

This species of manure, though transient in its effects, is of much importance in the districts where it can be obtained, adding greatly to the value of the neighbouring farms. It may be laid on the land at the rate of from twenty-five to forty cart-loads, or more, to the acre. It is more efficacious in the case of the light soils than the clayey; and hence, when a farm has access to it, it is better to apply the sea-weeds to the lighter, and the dung to the stiffer, soils of the farm.

Peat is a substance which may be used as a manure; but unless freed from its peculiar principles, it may remain for years exposed to water and air without undergoing decomposition, in which state it can afford no nourishment to plants. Pure peat, therefore, should be made to undergo decomposition before it is applied to the soil. This may be done by long exposure to the air, or by mixing it with quicklime, which decomposes its woody fibre, and forms a kind of compost, which, however, is not greatly valued.

But the woody fibre of peat may be better decomposed by mixing it with dung, or any animal matter. For this purpose, the peat may be carried directly to the farm-yard, and spread upon the heap of

dung, so as to be mixed equally with it. This is the most easy method of decomposing peat; but care is to be taken not to supply it in so large a quantity as to injure the quality of the manure. Peat may be decomposed, too, by mixing it in alternate layers with fresh dung in a fermenting state, the peat being first partially freed of its moisture by being for some time exposed to the air. The quantity of dung should be nearly equal to that of peat; and when the mass has arrived at the degree of blood-heat, it should be turned over and formed into another heap; and this should in like manner be turned before being used. This species of compost, however, often disappoints expectation, perhaps from the peat still retaining some principles unfavourable to vegetation.

Another class of manures consists of the Ashes of plants.

By burning plants, the greater part of their organic substance is lost, and what remains is a part of their carbonaceous, and their earthy, alkaline, and saline constituents. But the latter supplying to the soil the substances which the living plants consume, and acting on the matters of the soil, ashes form a manure of considerable efficacy, although, for the most part, their effects are little permanent.

In the clearing of the woods of newly settled countries, the trunks and branches of the felled trees are frequently burned, and the ashes spread upon the surface. They produce a powerful and immediate action, the potassa of the plants affording the substance especially required for rendering soluble the accumulated mass of vegetable matters in such soils.

In this country, the ashes of wood can rarely be obtained in the quantity required for manure; but the ashes of peat and turf, which contain much vegetable matter, are frequently employed, either in the process of paring and burning, to be hereafter described, or in the case of the residue of fuel, where such substances are made use of, or by burning them expressly for manure.

The ashes of peat are a very compound substance, containing much clay and sand, and various earthy and alkaline compounds. In the north of Scotland and in Ireland, where peat is the principal fuel, the ashes are necessarily applied to the ground as manure.

But for the most part, they are very transient in their effects, and far inferior to the dung of the farm-yard. Sometimes, however, they contain sulphate and even phosphate of lime in such quantity that they acquire a peculiar value, and are applied to turnips, and to the clovers and other herbage-plants with excellent effect. Of this character, are certain peat-ashes in England, produced chiefly in the countries of the chalk, as in Wiltshire and Berkshire. In Holland, certain ashes are produced by the burning of turf taken from low marshes, which are covered during the winter season with brackish water. They are strewed upon the surface of growing crops of different kinds, chiefly the clovers and other leguminous herbage-plants. They are carried to considerable distances inland for this purpose, and sown at the rate of about 20 bushels to the acre. They have been brought to this country, and employed with good effect, but the demand has not been sufficient to encourage the importation.

Sea-weeds yield ashes which may be applied with great benefit to any kind of crop. In the islands of Jersey and Guernsey, and all along the adjoining coast of Normandy and Brittany, these ashes are esteemed beyond any other substance for manure. The plants are shorn from the rocks at stated periods, and when not used in the fresh state, are either burned directly for manure, or employed, in the first place, by the inhabitants as fuel.

On the western and northern coasts of Scotland and Ireland, the marine plants of the rocky shores are burned for yielding the impure carbonate of soda called Kelp. The ashes are liquefied by the heat, and, on cooling, form a hard compact mass, containing from 2 to 5 per cent. of the carbonate. This substance, being pounded and spread upon the ground, forms an active manure, in the using of which, however, the precaution is required of not applying it in too large a quantity, or too directly to the roots of young plants. This substance is easily portable, and now that the barilla of commerce is so largely substituted for kelp, and that the means have been found of preparing the carbonate from common salt, it would be desirable to extend the use of this substance as a manure, so as to afford subsistence to the numerous and hardy

population so long dependent on the kelp manufacture. The only reason for melting the ashes into kelp in this case is, that they may be rendered more portable and capable of preservation; for it is quite sufficient to char the ashes without causing them to liquefy.

The ashes of Coal are employed as manure, forming a large part of the refuse matter of towns. The ashes of coal, when employed in the separate state, are most conveniently spread on the surface of meadows as a top-dressing. They are efficacious when so applied, and improve the stiffer clays by rendering them more loose and pervious to the air.

Another product of the incineration of plants is Soot, which is a deposition from the smoke of wood and coal, and is necessarily obtained in large quantities from the innumerable chimneys of this country. It consists chiefly of charcoal in a fine state of division; but it contains likewise various compounds, amongst which are acetate and other salts of ammonia, to which, it may reasonably be supposed, a part of its effect as a manure is due.

Soot may be applied to any kind of crop, but it exhibits most efficacy in the case of the cereal and other grasses, communicating to the leaves a dark green colour. It may be strewed upon the surface of the growing plants, either by the hand from a sheet or basket, or better by a machine. It may be sown at the rate of from 12 to 15 bushels to the acre, or more; or it may be deposited along with the seeds of plants sown in rows, in which case a small quantity will suffice to produce a vigorous growth of the stems and leaves,—a point of peculiar importance in the first stages of the growth of such plants as the turnip, the carrot, and the beet.

The addition of Carbon in different forms to the soil is doubtless beneficial. It is the mixture of this substance with the upper stratum, which mainly distinguishes it in colour and texture from the subsoil; and there can be little doubt but that the continued addition of carbonaceous matter to the soil by the regular application of manures, is one of the means of communicating to it a greater degree of permanent fertility.

The Seeds and Seedvessels of plants form a manure of great

efficacy. They contain more or less of nitrogen, with a large proportion of earthy and alkaline salts. In the countries of the south of Europe, the seeds of the lupine and other plants are sometimes dried, so as to destroy their germinating power, and applied with admirable effect to revive the languishing olive and orange trees. But the cases in which this class of substances can be employed as manure are very rare. With us their use is confined to the refuse of certain seeds from which the oil has been extracted.

Rape-cake is the husk and refuse of the seed of the rape, after the oil has been expressed. It is reduced to a coarse powder by grinding, and in this state it is scattered upon the surface, and slightly covered, when it attracts moisture and speedily decomposes. It may be spread upon the tilled surface of any land just before the seeds are sown, at the rate of 10 or 12 cwt. to the acre. In this manner it is applied to wheat and the other cereal grains. It may be deposited likewise with the seeds of the cereal grains when sown in rows, and likewise with the seeds of the turnip and similar plants, at the rate of 4 or 5 cwt. to the acre, in the manner to be afterwards explained. It is sometimes employed as a top-dressing to clover and other herbage-plants, though it is better that it be mixed with the soil. It is efficacious in the case of a single crop, but is little permanent in its effects. It is more efficient in moist seasons than in dry, and is better adapted to the clayey soils than to the dry and light.

Rape-cake is a favourite manure of the Flemings, who employ it in larger quantities than is customary in England, and frequently dissolve it in urine, forming a manure of the richest kind.

Oil-cake is a similar substance, being the refuse of the seed of flax. But oil-cake is too costly to be much used as a manure, its proper destination being the feeding of the animals of the farm. The refuse of the seeds of the poppy, as well as of all the oleaginous plants, may be employed beneficially as manures.

The seeds of the cotton plant, which formerly, in the United States, used to be allowed to accumulate and run to waste, form a peculiarly rich manure of this class. They might formerly have been imported with profit into this country; but the American

farmers have now learned to employ them in their own improving agriculture.

Malt-dust consists chiefly of the radicle of the seed, which germinates in the process of malting. This substance is given as food to animals, and is likewise employed as a manure. It is applied at the rate of from 30 to 40 bushels, or more, to the acre. It is sometimes used as a top-dressing, but it is more advantageously mixed with the soil. It is sufficiently enriching to the crop to which it is applied, but exercises little permanent action on the soil itself.

The next class of manures consists of those of Animal origin. All these substances exercise a powerful action on growing plants, and the use of them has been known from the earliest periods of agriculture.

Ammonia is one of the products of the putrefactive fermentation. It is composed of nitrogen and hydrogen alone, and only exists, at common temperatures, in the state of gas. It is rapidly absorbed by the water of the soil. It has the properties of an alkali in a high degree, and, combining with acids, forms salts. It is found as a carbonate in the greater number of putrefying animal matters, as a muriate in human urine, and the excrements of animals, as a sulphate in numerous substances. Its compounds have been found to promote, in a high degree, the growth of plants ; and animal manures contain its salts, or produce them during decomposition. The salts of ammonia are therefore indirectly employed, through the medium of animal manures. Two of these, the muriate and the sulphate, can be easily prepared. All analogy leads us to the conclusion that they would eminently promote the growth of plants ; but experiments are yet wanting to shew how far they can be safely, beneficially, and economically applied in the separate state. The refuse water of gas-works, which contains salts of ammonia, has been recently applied, in a diluted state, to meadows, with striking effect.

The Blood, Flesh, and Intestines of the larger animals are sometimes employed as manures. These substances, consisting in a great part of water, undergo a rapid decomposition when in

contact with the air; and they should therefore be covered by the soil before their particles have been lost by evaporation, or else largely mixed with earthy substances, and formed into a compost. The latter is generally the preferable practice with regard to them, because they then act in fertilizing a large quantity of matter. The refuse of the shambles furnishes the largest supply of this kind of manure, and is a very valuable substance when it can be obtained.

Fishes form an exceedingly powerful manure. They are sometimes to be procured in large quantity in the neighbourhood of fishing-stations, and in such cases they may be mixed with mud, turf, and other earthy matters, and formed into composts. In certain cases, herrings, pilchards, sprats, and even fresh-water fishes in the brooks of the countries of the Fens, are obtained in such quantities that they are procured by the farmers at a low price, and applied to the ground before they have undergone decomposition. Nothing can exceed the richness of this kind of manures, and almost the only precaution to be observed is, that they shall not be employed in such quantity as to produce an over-luxuriance of the crops of corn. On the coasts of Essex, Kent, and Suffolk, such quantities of sprats are taken by the fishermen, that they are sold to the neighbouring farmers at the rate of 6d. or 8d. the bushel, and applied by them to the land at the rate of from 20 to 40 bushels, or more, to the acre.

Animal Oils may be employed as manures, but they are generally too expensive to be so used. Sometimes, however, refuse oil can be obtained on moderate terms. It may be applied at once to the soil, or mixed with earthy or peaty matter, and the saturated mass laid on the ground as soon afterwards as possible. Animal oils contain no nitrogen, and yet they are in the highest degree enriching to the crops to which they are applied.

Another class of manures consists of the Bones of animals.

Bones consist in part of a gelatinous or albuminous matter, and in part, of phosphate of lime, carbonate of lime, soda, common salt, phosphate of magnesia, and fluoride of calcium. The gelatinous portion may be supposed to produce the action which

all other animal matters produce, but the principal effect must be ascribed to the salts of lime, and chiefly to the phosphate.

The use of bones as a manure was known in England so long ago as the year 1776; but it is only within these last twenty-five years that their use has been generally extended, and that they have been regarded as one of the most important subsidiary manures of the farm. They are now carefully collected at home, and largely imported from other countries.

Bones may be roughly broken into fragments, and in this way applied to land; but under the better management now adopted, they are reduced to a coarse powder by being passed between cylinders with strong iron teeth. The following figure represents a bone-mill of good construction, designed to be driven by steam or water power, and calculated to manufacture 5 tons or more in the day.

Fig. 4.

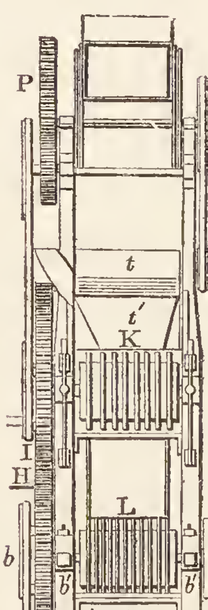


Fig. 5.

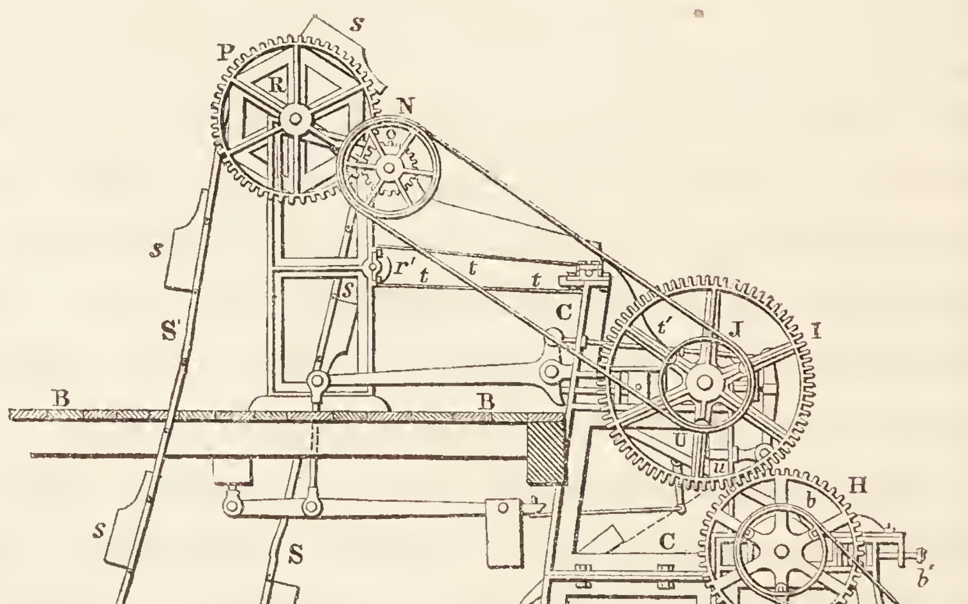


Fig. 4 represents an end view of the machine; fig. 5 a side view. A A A represents the ground-floor of the building in which

the machinery is contained; B B, the second floor; C C C C C C, the frame of the machine, formed of cast-iron; D D, the lying shaft from the moving power, carrying on its extremity the pinion E, which gives motion to the train of wheels F G H, with their pinions, pulleys, &c.

The bones to be ground are thrown into the buckets *s s s s*, on the endless chain S S S. Being elevated by the buckets, they are deposited on the endless web *t t t*, by which they are carried forward, and fall down a slide *t'*, between the first pair of rollers K. These rollers are bound round with a series of serrated discs, as at K, L, and M, the discs of one roller working into the intervals of the other, and moving in opposite directions. By the action of these two rollers the bones are coarsely bruised. Falling from the rollers, the bones pass along the slide *u* to the second pair of rollers L, formed in the same manner as the first, but with the teeth more closely set. The bones are now reduced to a finer state of division, and pass by the spout *m* to the revolving riddle *a*. The particles that are small enough drop through the holes of the riddle into the spout *y*, and are by it conveyed to the outside of the machine, and fall to the ground. The larger particles pass along the riddle to its extremity, and fall between the third pair of rollers M, by which their size is further reduced. They are then conveyed by the short spout *m'* to the second riddle *e*, through the holes of which the finer particles drop, while the coarser particles pass on to the end of the machine; whence they may be conveyed again to the buckets, to undergo a repetition of the process. There is a contrivance, by means of a set of levers, to cause the first pair of rollers to start asunder, when any hard substance that cannot be broken is mixed with the bones. To illustrate this, and the other details, there are various letters in the figures; but it is not now necessary to refer to these, the purpose here being, not to describe the parts of the machine in the detail, but to explain its general form and mode of action.

Bones are sometimes employed after they have been digested in water for the extraction of oil, and this process does not seem materially to affect their action. Sometimes they are obtained

in the calcined state, but these calcined bones are regarded as of inferior value to the others, and are sold at a lower price.

Bones may be applied to any kind of crop, but they are most largely employed in the case of the turnip, the carrot, and other plants cultivated for their roots. In this case they may be deposited along with the seeds, in the manner to be hereafter described. The quantity applied under this system is about 16 bushels to the acre; and the effect being to produce an early development of the leaves, this slight application suffices, under favourable circumstances, to insure a productive growth of the plants.

Bones may likewise be applied to the cereal grains, and either deposited along with the seeds, or previously mixed with the soil; or they may be applied to land in herbage, in which case they are simply spread upon the surface.

Bones may also be formed into composts with earthy matters, and thus allowed to decompose in the heap. When placed in a mass by themselves, they speedily begin to decompose; and it is the opinion of many, that they are superior as a manure when they have been subjected to an incipient fermentation of this kind. This may be supposed to be, because they are then in a decomposing state, and so fitted to act more immediately on the plants to which they are applied. But when they are reduced by grinding to a coarse powder, there is no necessity for subjecting them to any other fermentation than that which they will undergo in the soil itself. They decompose more quickly when the soil is dry and porous so as to admit the air, than when it is stiff and charged with water; and hence it is a popular opinion, that they are more efficient when applied to the lighter soils than to the clayey, and in dry seasons than in wet.

Bones, though used in comparatively small quantity, extend their influence beyond the crop to which they are applied. But a certain quantity of them seems to produce the maximum of effect on a given crop, and hence an increase beyond that quantity does not produce an increase of effect on the crop to which they are applied, although it does so on the succeeding ones. This may be supposed to be, because a certain quantity of the earthy

salts is required for the wants of the particular crop; and any increase beyond that quantity is useless, in so far as that crop is affected.

The employment of this manure has contributed in an important manner to the extension of the turnip culture in the British Islands. Being easily portable, it can be readily carried to a distance, and thus, in remote situations, it becomes a succedaneum, at a moderate cost, for the common manure of the farm-yard.

Horns, Hoofs, Hair, and Feathers, are appendages of the cuticular system of animals, and may all be employed as manures. Horn being largely used in the arts, it is only the raspings or shavings that can be obtained in any quantity in the separate state. Horn, and the same remark applies to the matter of hoof, is a very compound substance, but consists of a gelatinous mass, and differs from bone in this, that it contains only a minute proportion of phosphate of lime. Its action, therefore, resembles rather that of the muscular part of animals than the bony; but it is greatly more efficacious in proportion to the weight employed, though much more slowly decomposable. It is of the class of manures which may be beneficially applied to trees, in the case of which, a slow and not a rapid action is required: hence it is of admirable efficacy for the reviving of languishing fruit or forest trees, and for this purpose, is employed in the countries of the vine.

Hair and feathers are similar in their general composition and mode of action to horn. They are mixed with other matters in the general mass of refuse collected in towns and farms; but they are rarely to be obtained in quantity sufficient to be employed in the separate state.

Wool is a variety of hair; and woollen rags form a manure largely used. When it is considered that every inhabitant of the British Islands is more or less clothed in wool, it may be conceived how vast the quantity must be of this substance which is ultimately conveyed to the soil. This is done indirectly with the refuse matter of towns, but woollen rags form likewise an ex-

tensive article of sale in the separate state. They are necessarily exposed to adulteration by the mixture of linen and cotton rags, which, consisting chiefly of ligneous fibre, are much less efficacious.

Woollen rags are used at the rate of from 5 cwt. to half a ton to the acre. They are chopped into small pieces, and then strewed evenly upon the surface, and covered. They decompose slowly, and their action is therefore less immediate, but more permanent, than that of the softer part of animals. On this account they are of the class of manures that may be applied to trees; and hence they are largely used in the districts of the hop for manuring that plant. In the south of France, the Genoese pick up with care all the remains of woollen stuffs, that they may cause them to rot at the foot of their olive-trees. Woollen rags may likewise be beneficially applied to winter wheat, their gradual decomposition according well with the slow growth of the plant during the months of winter.

Shells, which are the hard covering of many marine and certain land animals, may be employed as manures. They differ from bones, in consisting chiefly, not of the phosphate but of the carbonate of lime. Containing, however, a certain quantity of animal albumen, they are more efficacious than the mineral carbonate. Shells may be mixed in any case with the dung of the farm-yard, or the matter of compost heaps. The shells of oysters are sometimes to be obtained in such quantity that they may be employed in the separate state, in which case they should be well pounded before they are applied to the land.

Many other animal manures may be obtained from the refuse of different manufactories, in which the skin, wool, and other parts of animals are employed.

The refuse of the tallow-chandler, being the sediment deposited by the melted tallow, is frequently disposed of for manure. It is in hard cakes, termed Graves, and sold at about L.5 the ton. It is spread on the land, and then covered, at the rate of half a ton or less to the acre, the graves being first cut with a hatchet, and then bruised in the manner of bones.

The scum of the sugar-refiners consists chiefly of blood, charcoal, and lime. It is applied at the rate of two tons or less to the acre, either as a top-dressing to meadows, or mixed with the soil, to any kind of crop. It is a very efficacious and lasting manure.

The next class of manures consists of the Excrements of animals, namely the urine and dung, which afford the largest and most constant supply of this kind of substances.

All the food of herbivorous animals, and, consequently, all the food of animals that subsist on them, is derived from plants. The food being received into the alimentary canal, is, by a marvellous system of organs, converted in part into blood, from which is secreted the matter of the flesh, the fat, the bones, the hair, and other parts of the body. A part, however, only of the food consumed is necessary for supplying the demands of the system; and what is not required for this end is expelled from the body. The excess of carbon in the blood combines in large quantity with the oxygen of the air which is drawn into the lungs, and escapes as carbonic acid into the atmosphere; not, however, to be lost, for nothing in nature is lost, but to be brought back again by myriads of leaves hung in the air to absorb it. Another part of the secreted nutriment escapes through the pores of the skin, to be brought back again, it may be believed, to the earth by the rains which purify the atmosphere. Another, and the larger part, is not converted into blood, but, after yielding its nutrient principles, is expelled from the system as fæces, a substance which, in every age, the reason of man has taught him to collect and apply again for the nourishment of new generations of plants. These fæces consist of two parts, the liquid, which is extracted from the blood in the kidneys, and the solid, which has not been converted into blood, but passes through the intestinal canal.

The urine of animals is a highly compound substance. It consists chiefly of water holding in solution various matters extracted from the blood, which pass through the urinary passage. It consists,

1. Of water, amounting to from 65 to 95 per cent., according to the kind of animal.

2. Of numerous products containing nitrogen, as urea, uric acid, mucus, &c.

3. Of various earthy and alkaline salts, as phosphates of lime, magnesia, soda, and ammonia, muriate of ammonia, sulphates of potassa and soda, common salt, and other substances.

But the urine of different animals differs greatly in its composition. In human urine, there are phosphates; in that of the larger herbivorous animals there are few phosphates, but abundance of muriates, sulphates, and carbonates.

Urine, from whatever animals derived, is a very fertilizing substance. It may be employed either by itself, or mixed with the litter of the stables and farm-yard, or the matters of the compost heap. When applied alone, it ought to be permitted to become stale and putrefy, in which case certain chemical changes take place, which fit it better for acting on the plants to which it is applied.

When urine is used alone, it is carried to the field in casks or other vessels, and spread upon the surface in the manner in which we water streets and highways. It may be applied to any kind of crops when growing, and with us is most usually applied to forage and herbage plants. This is a species of watering applied to the plants themselves, which scarcely fails to produce an immediate and beneficial action.

The solid excrements of animals are usually mixed with a portion of urine, and with the litter and other refuse matters of stables, farms, and towns. They are very different in their composition in different animals, and even differ, within certain limits, in the same animal, according to its age and the food with which it is supplied. They contain more of carbon, and less of nitrogenized compounds, than urine. They are slower in their effects than urine, but their action extends over a longer period.

Of this class of substances is Night-Soil, which abounds more in soluble salts and nitrogenized compounds than other solid excrements. It is usually employed as a manure, mixed with the general mass of excrementitious and other matters produced in towns and farms. It is a very efficient manure, and may be ap-

plied to any kind of crop, and in any form ; but having been rendered, for a useful end, offensive to the human senses, the using of it is disliked, and less care is bestowed on the preservation of it than of any similar substance. In England, especially, a vast proportion of it is lost, by being carried away in the sewers of our innumerable towns. Yet by easy means it can be deprived of the effluvia which render it offensive, and applied to the most useful purposes.

The usual method of depriving this substance of its odour, and rendering it capable of preservation, is by mixing it with carbonate, but much better with sulphate, of lime, and charcoal. Being then cautiously dried, it may be preserved for use. The most economical mode, however, of employing it is in the recent state, as practised in Italy and Flanders, and other parts. In Flanders, where extreme attention is paid to the collection of animal manures, it is diffused in water, and applied in a semiliquid state to growing plants, in the same manner as urine ; and in Switzerland a similar practice prevails. In China it is mixed with marl and dried, and in this manner made into cakes, and rendered a subject of commerce. When these cakes are to be used, they are diffused in water, and the liquor is applied to growing plants, a method of manuring which seems to be preferred by this frugal and laborious people. In France and other countries of Europe, attempts have been successfully made to preserve it, by mixing it with lime, gypsum, and carbonaceous or earthy matters. This has been deemed a matter not undeserving of the attention of governments. In London, and other towns in England, attention has been more tardily given to the same subject, and establishments have been formed for preserving and collecting the material. From the habits of society, however, it is more difficult to effect this purpose in England than in any other country. From the extensive system of sewers established, the waste of this substance is immense. From the city of London, with its million and a half of inhabitants, there is daily carried down the Thames a quantity of fæcal matters which would fertilize a large tract of land. With singular inconsistency, the same people that cannot endure the

odour of this substance, suffer it to pollute the noble river whose waters they use for so many purposes. In every town the same neglect, in a greater or less degree, occurs. Everywhere vast masses of fertilizing refuse find their way to the neighbouring rivers or brooks, and are carried to the ocean, which could, by the easiest means, be collected into tanks, and employed to enrich the country around.

The usual method, it has been said, of preserving this substance, and rendering it portable, is to mix it with lime, or better, with gypsum, and charcoal. In these ways it is prepared for use in Paris, Berlin, and other towns of the Continent; but where the mixed matter of sewers is conveyed to tanks, mud and the ashes of turf may be substituted for charcoal, and carbonate of lime for gypsum.

The Dung of Birds is a more efficacious manure, weight for weight, than any other of the same class. It consists of the liquid, as well as the solid fæces of the animals. That which is used in this country is derived from pigeons and domestic fowls, though, from the small quantities in which it can be obtained, it is usually held to be of secondary importance. It should be spread evenly on the surface of land in tillage, and then slightly covered; or it may be dried and deposited in the state of powder, along with the seeds. When exposed to moisture, it speedily decomposes, so that, when it is to be preserved for use, it should be kept dry.

Guano is the dung of sea-birds, first brought to this country from the rocky shores of Peru, and certain uninhabited islands near the coasts, where, under the influence of a placid clime and dry atmosphere, it has accumulated in vast beds, which are sometimes covered with soil and drifted sand. It appears to have been used by the ancient inhabitants of the country, and is still largely employed by the Spanish Americans, as the most precious manure for the maize and other plants cultivated in the arid plains of their country. It has likewise been obtained from the rocky island of Ichaboe, on the coast of Africa, and has been discovered in other islets near the same continent. But the African guano is

inferior to that of Peru, and sells, accordingly, at a lower price. Guano is likewise produced in considerable abundance on the coast of Malacca, and various islands of the Eastern Archipelago. It is there found in caverns ; and is partly the produce of the larger bats, which feed on fruits, and partly of insectivorous birds, probably of the swallow tribe. The former is much inferior to the latter, and, being the only kind that has been brought to Europe, the guano of the East is held in little estimation. It has been used by the Chinese and Malaccans time out of mind for the manuring of their rice and other plants.

Guano is in the form of a brown powder, blackening when heated, and giving off ammoniacal fumes. It has been analyzed by various chemists, and found to contain phosphates, urates, and other salts. It is, beyond a question, the most valuable of all the animal manures which have been imported into this country. It is calculated to add, in a material degree, to the produce of the British Islands, and, from its portable nature, to afford increased facilities to cultivation in the remoter districts. It is applied to the soil at the rate of from 2 to 4 cwt. to the acre, either alone, or along with the manures of the farm-yard.

Other animal products might be mentioned as adapted for manuring land ; but the law is universal, that all animal substances fertilize the soil, and promote in an eminent degree the growth of plants. Attempts have been made to arrange manures in a scale of value, according to the quantity of nitrogen which they contain. But the relative value of manures cannot be determined by this single condition ; for manures operate through the medium of their earthy and saline constituents, as well as their nitrogen. Yet it is perfectly true that nitrogen is an important constituent in manures, producing putrefaction not only in the compounds into which it enters, but inducing similar action in other substances.

But of all the sources of supply to the farm, the most important is the manure of the farm-yard. In all cases, where an extraneous supply cannot be commanded, the farmer must rely upon the produce of his own fields, and the animals of his farm, for affording him the means of maintaining the fertility of his land; and

all the other manures which he can obtain must be regarded as subsidiary to this the main source of his supply.

The dung of the farm-yard is the produce of the hay, straw, turnips, and other substances used as provender or litter upon the farm. It is collected into one or more yards, and fresh litter and all other refuse being added to the mass, it gradually accumulates until it is carried out to the fields for use.

The manner of feeding cattle in their houses and yards will be afterwards explained. It is sufficient, with relation to the present subject, to observe, that the larger cattle may either be fed in stalls in houses, or in yards in which they receive their food. When they are fed in houses, their dung and soiled litter are carried to the heap in the yard, where it gradually accumulates; and when they are fed in yards, their dung, in like manner, accumulates there, being in the mean time compressed by their treading upon it.

In the practice of the farm, to be afterwards especially described as suited to the circumstances of this country, the larger cattle of different kinds are brought home to their houses and respective yards before winter. Some are kept in their stalls in houses, and their dung and soiled litter are carried out daily to the yards, while others receive their food in the yards themselves, and thus tread upon the heap. In this manner the mass of dung accumulates during the period of feeding, and at the proper period, in the following spring or summer, is carried out to the fields and applied to the land.

The dung of the farm-yard is thus seen to be a collection of animal and vegetable substances. It consists of the excrements of the animals kept and fed upon the farm, together with the straw or other materials used as litter, and generally of the refuse and offal produced about the homestead. This mixed mass is collected during the period of feeding, when it undergoes a certain degree of fermentation. When trodden by the feet of the animals kept in the yards, the effect is to exclude the external air, and to prevent the fermentative process from proceeding with that rapidity which would take place were the mass not compressed.

The principal animal substances which are mixed with the ligneous fibre of the litter, and which cause it to undergo decomposition, are the dung and urine of the animals.

The properties of this dung, to a certain extent, depend upon the kind and age of the animals, and the nature of their food. When the animals are fed on straw and the dried stems of plants, the dung is less rich than when they are fed on turnips, oil-cake, and other nourishing food. The dung of the different animals is mixed in greater or less proportion with their litter; and the greater the proportion of the animal to the vegetable matter, the more readily will the litter ferment and decompose.

The urine of the animals, it has been seen, is a very rich manure, and contains, in certain states of combination, all the elements which enter into the composition of plants. It is necessarily mixed with, and partly absorbed by, the litter and other substances in the yards, and it hastens, in a material degree, the decomposition of these substances.

The urine, however, is apt either to make its escape by flowing out of the yards, or to be imperfectly mingled with the litter. It becomes, therefore, a part of the management of the farm-yard to provide against either of these contingencies.

The farm-yard should be made level or slightly concave at bottom, and the bottom should be sunk somewhat below the surface of the ground. As a portion of the liquid will flow from the stables and feeding-houses, gutters of stone should be made to convey the liquid from these into tanks or other reservoirs adjacent to or in the yards. The same means are to be taken for conveying away any excess of liquid from the yards themselves. This is not done for the purpose of draining the yards of moisture, which would be an error, but for the purpose of preventing any excess of liquid from being lost. The principal cause which produces a great flow of liquid from the yards, is an excess of rain, which, falling upon the heap faster than it can be aborbed, washes away the urine.

Three methods may be adopted for the management of the liquid

which is obtained from the feeding-houses, or which oozes or is washed off from the mass in the yards.

1. It may be pumped from the tank or reservoir into which it had flowed, conveyed back to the farm-yard, and spread over the surface of the heap. In this manner it will be imbibed by the litter, and tend to hasten the decomposition of the mass; or, if there be a compost heap upon the farm, the liquid may be spread upon it so as to be imbibed by it.

2. It may be pumped up when convenient, and conveyed in barrels to the field, and spread over the surface,—a species of manuring which, under certain circumstances, is exceedingly efficacious.

3. In the bottom of the tank or reservoir to which the liquid is conveyed, may be placed earth, turf, mould, and other absorbent substances. These being saturated, will become very rich manure, and may either be carried from the tank to the field, and applied to the ground, or put into heaps or composts, until the period of using them shall arrive.

Of these methods of applying the excess of liquid from the feeding-houses and yards, the most generally applicable to the common practice of farms in this country, is the conveying of the liquid back to the yards, or the spreading of it over the surface of compost heaps, or other collections of absorbent substances. In Flanders, where extreme care is bestowed in the collection and preparation of liquid manures, there is a smaller proportion of straw and hay produced on farms, than in the mixed system of agriculture of Britain. There is not, therefore, so great a proportion of ligneous fibre to be decomposed. The Flemings, accordingly, pursue the mode of managing their manure which the circumstances peculiar to their agriculture render expedient. They can always ferment sufficiently the fibrous matter of the heap of their farm-yards, and therefore they have always a spare supply of liquid in a separate state. But, in this country, where we aim at producing a large quantity of hay and the cereal grasses, we require nearly all the liquid of the animals to moisten and ferment the general mass of the farm-yard.

When the animals of the farm are fed on tolerably rich and succulent food, and where the proportion of straw is not too large, there is no difficulty in fermenting the mass of the farm-yard to the degree required ; but when the quantity of straw is very large in proportion to the more moist and succulent food consumed, as sometimes occurs in the case of clay-land farms, then there may be considerable difficulty in getting the straw sufficiently decomposed for use. This may arise from the want of moisture, as well as from a deficiency of animal matter ; and as we may not at the time have a power of supplying the latter, we must endeavour to keep the heap moist, by soaking it, in the absence of rain, with water. But the permanent remedy for this evil is to increase the quantity of such nourishing food as the farm will produce,—namely, cabbages, tares, clovers, and other succulent and nutritive plants.

Sometimes, even when there is no extraordinary excess of litter, the fermentation of the heap in the yard, after proceeding to a certain degree, suddenly stops, by which the manure is much injured. This arises from the want of moisture ; and when it happens, it is often very difficult to renew the fermentation. The best remedy is to turn over the heap, soak it with water, and mix it with horse-dung, or any animal offal that can be obtained.

With these exceptions, the management of the farm-yard is not attended with any difficulty. We have seen that the mass consists of a collection of the excrements of the animals kept upon the farm, of the straw, and other substances employed for litter, and generally of any refuse or offal produced at the homestead ; and that this mixed substance is accumulated chiefly during the months of winter, undergoing during this period a certain degree of fermentation and decomposition in the yard where it lies.

The substance thus collected and partially fermented, is to be applied to the grounds during the months of spring, summer, or autumn, immediately following the winter in which it has been prepared. It should be always applied as soon after it is prepared as possible, there being a waste either in retaining it too long, or

in causing it to undergo a greater degree of fermentation than is required.

In the process of the putrefactive fermentation, the elements of the body fermented, in assuming their new forms of combination, partly make their escape in the gaseous state. In the fermentation of manures, the decomposition may proceed so far that the great mass of the substance shall be exhaled, leaving behind only the earthy and alkaline, and a portion of the carbonaceous, matter of which it was composed. In the treatment of this class of substances, therefore, the putrefactive fermentation should neither be continued longer, nor carried to a greater degree, than is necessary for the purposes intended.

In practice, our purpose is to produce certain kinds of crops; and certain kinds of plants, it is found, require a greater action of manures at particular stages of their growth than others. Thus, the turnip, the carrot, and the beet, which are sown, as will afterwards be seen, in the early part of summer, require that the manure applied shall be in such a state of decomposition as to act upon and nourish them in the first stages of their growth; and if this be not so, the crop may entirely fail. In these, and similar cases, accordingly, a complete preparation of the farm-yard dung is an essential point of practice.

Certain plants, again, do not require the same state of decomposition of the dung. Thus the potato requires less in the first stages of its growth than the turnip; and hence it is not necessary to subject the manure to be applied to the same degree of fermentation.

In some cases, too, as in the process of the summer-fallow, to be afterwards described, the manure is mixed with the soil some time before the seeds of the plants to be cultivated are sown. In such a case the manure undergoes the necessary fermentation in the soil itself, and does not require that previous preparation which, in the case of the turnip and some other plants, is required.

But while no necessity exists for fermenting the matter of the farm-yard beyond the degree requisite for the special purpose in-

tended, it is always a point of good practice to ferment it to that degree. In order to know when dung is sufficiently fermented for the particular use required, a very little practice and observation will suffice. When it is fully fermented, the long stems of straw which formerly matted it together, are in such a state of decomposition, that the parts can be readily separated by a fork. It is not necessary in any case that it be in that extreme state of decay in which we often see it used by gardeners, and when it can be cut by a spade like soft earth. Whenever farm-yard dung has been fermented to this degree, it has been kept beyond the proper time, and the management has been bad.

The mass, we have seen, is collected chiefly during the months of winter, and will always be ready to be applied to the ground in the spring, summer, or autumn, immediately ensuing ; and there is no case in which it is advisable to keep it beyond the year in which it has been collected.

A common and convenient practice is, to carry it out from the yard where it has been collected to the field where it is to be used, and there to pile it up in one or more large heaps, so that it may undergo the further decomposition required, before being applied to the land. Doubtless there is a certain waste of the volatile matter of the dung by this process, but it is frequently convenient in practice that the dung be thus carried to the field where it is to be used, so as to economize time at the season of more active labour.

When, accordingly, after the dead of winter, as towards the end of December, and during hard frosts and snows, the men and working cattle upon the farm cannot be otherwise employed, we may begin to carry out the dung to the fields where it is to be used. It is carried out in the carriages of the farm, into which it is lifted by large forks. This partial carrying out of the dung from the yards proceeds when occasion offers, or when the state of the weather prevents the other labours of the farm from being carried on. And when the cattle are finally removed from the houses and yards, and turned out to pasture, which, in the north of England, is generally by the middle of May, the whole remain-

ing dung may either be carried to the fields, or remain in the yards till required for use.

The dung, as it is carried out to the fields, is to be laid in the large heaps referred to, and which may be about four and a half or five feet high, and of such other dimensions as may be convenient. When the dung is placed in these heaps, it is in a state very favourable to further fermentation; for it is to be observed, that in all cases the turning over of the dung, so as to give access to the air, causes an increase of fermentation; and this is the universal method adopted by farmers and gardeners when they wish to give a greater degree of fermentation to any heap. Should the dung in these large heaps not ferment to the degree required, they are to be turned over, and formed into new heaps, the upper part being placed below, and what was before below at the top. By these means the fermentative process will be renewed; and should this turning not be found sufficient, the heaps must be again turned over, so that they may be brought to the degree of decomposition required. The large heaps of this kind should not be placed in a very exposed situation, so as to be too much acted upon by winds; and it is a good precaution, and a necessary one in very warm countries, to face up the sides with a little earth or turf, and to strew some earth, or better, a little earth mixed with gypsum, upon the top, so as to prevent the escape of decomposing matter. When it is wished to hasten the putrefactive process in these heaps, it is better that they be not compressed by the carriages going upon them to unload; but where there is no peculiar necessity for hastening the putrefactive process, the carriages and beasts of draught can go upon the heap without injury. When peculiar care is required, as when the dung has been imperfectly fermented in the yards, it should be spread over the heap in layers, so that one layer may undergo a slight fermentation, before it is compressed by that which is to be placed above it.

The mass may be also turned over in the yards where it lies, and allowed to ferment before it is carried out to the fields for use. In this case, the workmen begin at one side of the heap, and with

large forks turn it over, laying that underneath which was before uppermost, so as that the whole may be reversed. If after this process of turning, no treading of cattle is allowed, the fermentation of the mass will proceed with rapidity, and then the whole may be carried out at once from the yards to the fields for use. This method will not only in certain cases be the most convenient, but will save some of that waste of the volatile matter of the heap, which takes place under the other system.

Where the dung produced is very rich and well decomposed, as where cattle have been feeding in stalls on juicy and nutritive food, it may not appear to require this turning over to fit it for use; yet even in such a case it is generally beneficial that it be turned over at least once before being used, the effect being to ferment the mass not only sufficiently but equally, and to mix its different parts together. It may be observed, also, that when the mass of vegetable and animal substances is thrown into a common yard, some care should be bestowed in spreading it equally, so that one part of the yard may not be filled with rich dung, and another with poor. The dung of horses, for example, is more susceptible of quick fermentation than that of oxen. When the stable, therefore, opens upon a common yard, the horse-dung should not be suffered to accumulate in a mass about the stable, but spread abroad upon the general heap.

Farm-yard dung is chiefly applied to the soil by being spread upon the land when in tillage, and covered by the plough. The periods at which this is done, and the manner of doing it, will be afterwards pointed out. By being covered by the earth, the dung soon passes through its course of fermentation, and becomes decomposed, and mixed or combined with the matter of the soil.

This valuable substance must be economized in the manner of applying it. The soil must be kept as rich as the means at the farmer's command will allow; but it is an error in practice to saturate it at one time with manures, and to withhold them at another. They ought rather to be applied in limited quantity and frequently, so as to maintain a uniform or increasing fertility in the soil.

Mention has from time to time been made of Composts. A compost, as the name implies, is a mixture of substances; and composts may be either special or general. The first class consists of those, in forming which the design is to prepare any given substance for use as a manure. Thus, when peat is mixed with dung, the compost is formed especially to promote the decomposition of the peat; when sea-ware is mixed with earthy matters, the purpose is to decompose and preserve the matter of the marine plants; when night-soil is mixed with charcoal and gypsum, the object is to preserve in a suitable form the matter of the night-soil.

General composts, again, are those in the case of which the design of the farmer is to collect and preserve for use all substances which may fertilize the soil. The mass of the farm-yard may thus be said to be a general compost; but its essential destination being to prepare the excrements and litter of the animals of the farm, it is in this sense a special compost. Those to be now referred to consist of one or more heaps, in which fertilizing substances of every kind are deposited, as the occasions for obtaining them present themselves. They are, accordingly, receptacles for manures, and their contents accumulate in proportion as the manures can be collected upon the farm or elsewhere.

Animal substances produce, it has been seen, the decomposition of vegetable matter by mixture or contact. When vegetable matters, therefore, are to be decomposed in the compost heap, they should be mixed or placed in contact with animal substances, or with the mixed matters of the farm-yard in a decomposing state. But the volatile parts of the decomposing mass tend to make their escape. To retain these, the heap should be mixed with earthy and carbonaceous matters, such as turf, mud, marl, the cleaning of ditches, the sludge of ponds, the scraping of roads. These earthy matters are designed to prevent the escape of the decomposing particles, by affording bases with which the nitrogenized and other compounds generated may combine. To aid this effect, lime should be mixed with the earthy matters, in the proportion of about a bushel of quicklime to a cubic yard of earth. This mixture should be prepared, in an adjoining heap, some time before, so that the

quicklime may become mild, and then be spread, as required, in layers over the putrescent matters deposited.

The animal substances to be covered in the heap may be of every kind which can be obtained ; as the residue of the shambles, fish, and the refuse of fishing stations, waste blubber, animals that die from accident or disease, night-soil, and, in short, all animal substances whatever, which it is not intended to apply in the separate state. The vegetable substances may be sea-weeds, the stems of potatoes, the leaves of trees, spoiled hay or litter, the stems and leaves of weeds, and any green substances, and, in short, any vegetable matter whatever which is not to be applied separately. To these may be added ashes, soot, or any similar substances. When any quantity of putrescent matters is laid upon the heap, it should be covered with a layer of the mixed earthy matters referred to. The heap should be oblong, for the convenience of adding to it, and 20 feet wide, or more. When there is a deficiency of separate animal substances, layers of farm-yard dung should be substituted, so as to keep the heap always well mixed with putrefying matters, and continually increasing. Urine, when it can be obtained from the tanks, should be spread largely on the surface, so as to sink down and be imbibed by the mass. When the heap is completed in height, it should be rounded at the top, and covered with a layer of earth mixed with lime, or with marl or gypsum. About a month or six weeks before it is applied to the ground, it should be turned over from top to base, and formed into a new heap, by which means its parts will be all mingled together. On being turned over, the temperature of the mass will rise to that of blood-heat or more, shewing that the fermentative processes have been resumed. One turning will suffice, if there is a sufficient quantity of animal matter, but in other cases a second turning may be necessary.

By attention to these simple rules, a vast quantity of the most useful manure may be collected and prepared, and occupation afforded to the men and working cattle of the farm when not otherwise occupied.

The chemical changes which take place in a mass so compound

cannot be pointed out; but if the mixture has been properly made, nitric acid will be formed in considerable quantity, which will combine with the lime and other mineral bases. This is, in truth, one of the modes in which nitric acid is in some countries obtained in the preparation of saltpetre. Carbonate of lime is mixed with dung and other putrefying substances, and the heap is defended from the rain, and frequently turned over. By these means, nitrate of lime is produced, which is afterwards decomposed by means of the alkaline base. But whatever be the nature of the chemical changes produced, the province of the farmer is sedulously to collect all animal and vegetable refuse which he can obtain, and when they do not admit of separate application, either to mix them with the mass of the farm-yard, or to deposit them in the compost heap. Opportunities are continually presenting themselves to the farmer of collecting substances which may be rendered useful, as the cleaning of his ditches and ponds, peaty matters, masses of mould, and the mud of roads, which consists of various minerals comminuted or ground by the action of carriages, and generally mixed with animal and vegetable matter. By mixing substances of this kind with lime, and this mixture again with the putrefying matters of the compost heap, he will never fail to add largely to the manures of his farm. It is a point of good husbandry to let nothing be lost; and this maxim steadily acted upon, will more avail the farmer in adding to his resources than the most laboured theories of vegetation. The great and common defect in the formation of composts, is the want of a sufficient quantity of animal matters in the heap. Many of the composts which farmers form are merely dry masses of earth and lime, which are useful in a certain degree when mixed with the soil, but in no degree comparable to the matter of a well-formed compost.

Analogous to the compost matter of the farmer is Street manure. This is the general refuse collected from the streets of towns, and is a very compound substance. It consists in large proportion of ashes mixed with offal and refuse of every kind. It is of great importance to the fertility of the neighbouring coun-

try; but it is much inferior in value to well rotted dung. From its bulk and weight, it is chiefly used in the vicinity of the towns where it is produced, except where the facilities of water-carriage allow it to be carried to a distance. In taking care that this substance be regularly removed from the streets of towns, it is the duty of public authorities to see that it is carefully collected, so that it may be rendered available for the valuable purposes to which it is applicable.

One method of supplying animal manure, is by keeping animals for a time on the same piece of ground, in order that their excrementitious matters may fall upon and be absorbed by the soil. This has given rise to the practice of folding, which consists in penning flocks of sheep, chiefly during the night, on a small space of ground. The pens are from time to time shifted, so that, in the course of the season, a considerable quantity of land is successively manured. We shall find, in the sequel, that the practice of penning is a beneficial one in the case of turnips, rape, and similar plants; but in such cases the manuring of the land is not the object of penning, but a consequence of it. The case where the practice is bad, is when sheep are confined to certain spaces, merely for the purpose of manuring the ground. The practice is carried to a most injurious extent in certain parts of England, where the animals are made to travel a considerable distance to the fold, and where certain breeds are even valued for their power to withstand this rude treatment.

Where the art of collecting and preparing manures is understood, and where a proper system of tillage is established, it can never be necessary to adopt such a practice, for the purpose of manuring land. It is the wasteful manner of applying putrefying manures in England, by spreading them upon the surface of grass-land, which produces, in any case, the want of necessary manure. Under a system of good husbandry, it is, in all cases, practicable so to adapt the modes of cultivation to the nature of the soil and other circumstances, that the farm shall possess the means of maintaining its own fertility by the production of manure; and the facility of doing so is increased to an almost unlimited degree, when

extraneous manures can be obtained in the quantities afforded in a rich and closely inhabited country.

III. TILLAGE.

Tillage, in the proper sense of the word, is synonymous with husbandry, but, in common language, the term is applied to the mechanical operations performed upon the soil. These operations, however, entering into all the business of the farm, they may be regarded as the foundation of husbandry in its wider sense.

The soil, independently of the labour of art, tends to produce the vegetation which is proper to it; and the greater part of the world yields only its natural plants. Even when cultivation has become an art, the farmer avails himself of the spontaneous produce of the soil, for the food of his animals, as in the case of his natural meadows, his uncultivated wastes, his marshes and mountains. But when men congregate into societies, even in the happiest climes and most prolific lands, the labour of tillage must be undergone, in order that human food may be supplied. The most useful plants will not grow, or will not arrive at the full development of their parts, without careful tillage. If the cereal grains exist in the natural state at all, which is doubted by many, it can only be within narrow geographical limits; and it is certain that, without the care of the labourer, they could not be multiplied beyond a single season over the greater part of the world. In the case of our most useful vegetables, the effects of cultivation have been seen to produce changes of character little short of those which distinguish species. The cabbage of our gardens and cultivated fields is, in its wild state, a feeble plant, yielding a few sea-green leaves: the carrot and the parsnep, in the same condition, produce roots so ligneous and acrid as to be unfit for human food: the beet is of a class of inconspicuous weeds: and the wild turnip is a plant with a small fusiform root, scarcely to be recog-

nised, by the common observer, as identical with the useful vegetable with which cultivation has rendered us familiar.

Of the modes by which tillage produces its effects on plants, one must be believed to be the exposing of the particles of the soil to the atmosphere, and the admission of air into its pores and interstices. Moisture and air have been seen to be necessary to produce, or hasten, those changes which matters of organic origin undergo in the soil, and to aid those chemical actions by which the matter of the soil is rendered fitted for performing its functions. The same agents appear to be no less required, in order to produce and assist the vegetable processes. It is in the upper stratum only of the ground, that germination takes place. If the seeds of plants are placed so deep in the earth that the air cannot reach them, they will remain for ages inert; and many cultivated plants will never grow with vigour, unless, by means of a careful loosening of the soil by tillage, the air shall be allowed access to the parts underground.

Experience has conducted the husbandmen of every age to the knowledge that the soil must be stirred, and its parts divided and comminuted, before it will yield its fruits to human labour. Nay, the same wants have almost everywhere led to similar means for arriving at the ends proposed. The instruments of tillage of the first ages are yet in use in many countries. The plough, the harrow, the hoe, and the sickle, of the ancient labourers of Egypt, were the same as those employed on the banks of the Ganges at the present hour; and all over the East, from Aleppo to the Sea of Japan, the implements of tillage of the first ages are yet those of the people. The plough of the Greeks and Romans was similar to that of the inhabitants of Syria at the present hour; and from Scandinavia to the mountains of Atlas, the form of this, as of all the other simpler tools of the husbandmen, was so much alike, that they almost seem to have been fashioned from some common model. So similar everywhere have been the practices of the husbandmen, as to have justified the poetical fancy, that the Gods had descended to the earth to teach the art of tillage. But the Divinity, it may be reverently believed, was in the Reason given to man, which has

enabled him, under every condition in which he has been placed, to resort to similar means for supplying the same wants.

In order to expose a new surface of earth to the atmosphere, the principal instruments in use have been the mattock-hoe of the countries of the East, the spade, and the plough. Of these instruments, those which perform the work most perfectly, but with the greatest expenditure of human labour, are the mattock-hoe and the spade. The ancient plough is merely the hoe drawn by domestic animals; but of this instrument, modern mechanical skill has formed a very admirable machine. The plough, as will be immediately explained, is essentially a wedge, which is calculated to raise up and reverse the soil, so as to expose a new surface to the atmosphere. This is the instrument which, in modern agriculture, is employed to turn up the soil: but, in performing this operation, it executes another, namely, that of dividing and comminuting the parts of the soil. There are other instruments, however, which are more especially designed to perform the latter operations, of which the type is the common harrow, all derived from the ancient rakes, or from the *crates* and *irpex* of the Romans,—themselves, perhaps, derived from the *henga* of the Eastern nations; and there is another class of instruments, formed from the ancient hoes, employed for the tillage of plants during their growth.

The soil may be turned over and divided before the seeds, roots, or tubers, are placed in the ground, and it may be tilled during the growth of the plants. The former class of operations may be termed preparatory, and the due performance of them is an essential point of good husbandry. The soil, as all experience shews, should be tilled to a considerable depth beneath the surface. This allows the roots of plants to extend themselves in the earth, and to derive their nourishment from a larger mass of soil. It removes the water which collects between the soil and subsoil to a greater distance from the roots of plants, without, however, depriving the soil of water; for it is found, that a deeply tilled soil remains more moist, even in the heats of summer, than one that is shallow. The useful effects of deep tillage are seen no less in the garden than in the fields. A corner of the most worthless common,

deeply trenched and manured, becomes at once a soil fitted for producing the culinary plants, and, in the abundance of its produce, is often seen to surpass the richest of the fields around.

The due performance of the preliminary operations of tillage is of primary importance in the practice of agriculture. It is by the proper construction, and right application, of the mechanical agents employed, that these purposes are to be effected. Yet, in a few places only, has the due knowledge of practice in this essential branch of husbandry, been arrived at. Over the greater part even of England, tillage is imperfectly performed; the ploughs are bad, and the waste of labour is enormous; and it cannot be doubted by any person of experience, that a vast increase might be made to the produce of the British Islands by a better system of tillage.

Tillage, besides being intended to turn up, loosen, and comminute the soil previous to placing the seeds, roots, and tubers, in the ground, is employed to cover these parts of plants with soil. The modes of doing this depend upon the kind of plant, the season of the year, and other circumstances. Tillage, too, is employed to cover the manures of the farm, and to mix them in the due time and season with the matter of the soil.

Tillage, besides being designed to prepare the land for the crops to be cultivated, is applied to plants when growing. The action here is likewise that of loosening and comminuting the soil, and the effects produced may be ascribed, in a great degree, to a due admission of the air into the pores and interstices of the earth.

In the garden, the hoeing around the roots and stems of growing plants is continually practised as the means of promoting their growth. In some of the warmer parts of Europe, it is customary, in the dry season, to cut a trench round the olive trees. In an arid climate this would seem calculated to dry up the moisture of the roots. The effect, however, is very different. The operation admits the air, charged with its aqueous particles, to the roots, and revives the growth of the plants, even in the hottest season. In India the Hindoos make deep ruts with their simple hoes between the rows of the growing plants, and this is done

when the heat of the sun is intense. In the countries of the vine and the hop, the stirring of the earth round the roots is continually practised. The sugar-cane, in the burning regions where it is produced, is subjected to the same treatment; and so likewise is the maize. The latter is a beautiful plant, growing with tall thick stems. The seeds are sown at such a distance from one another, either singly or a few together, that the intervals between the growing plants can be easily tilled. In the United States of America, it is a common practice to drive the ploughs between the rows, taking deep furrows. The effect of this simple process is remarkable. The increased growth of the plants testifies to the very eye the sudden benefit derived from admitting the air to their roots. In our own country, it is common to sow the cereal grains in rows, so that the intervals may be tilled. The stirring of the earth is seen to produce an increased growth of the plants, however dry the atmosphere may be at the time; and even the driving of the harrows rudely over the surface of growing plants is frequently practised, and found to be beneficial. At the beginning of the last century, Jethro Tull, an ingenious writer on English agriculture, from observing the surprising effects of a due tillage of growing plants, conceived the idea that tillage alone was required to produce crops of any kind, and that manures acted only mechanically, by allowing free access to the air. Tull defended his theory by numerous appeals to facts, tending to shew that crops of corn could be cultivated in continued succession, by performing in a proper manner, and in a due degree, the tillage of the soil. While the error of the theory is now admitted by every one, the facts are to this day valuable, as shewing the powerful influence of a due tillage and comminution of the soil in promoting the growth of plants. To the writings of this eminent individual is to be ascribed the introduction of the row culture into England, although the system was known to the Romans, and had been practised by the people of the East from the earliest ages.

Another and important purpose served by the tillage of the soil, is the removal or destruction of weeds. Where weeds grow,

the cultivated plants are interfered with in their growth, and deprived of their due share of nourishment. An essential branch of good husbandry is to free the land from all plants except those which it is the special purpose of the farmer to produce. Some of these plants propagate themselves by their seeds, and others by their roots and underground stems, as well as by their seeds. The latter class must, for the most part, be disengaged from the ground before they can be destroyed. In every country the incessant labour of the farmer is employed in effecting this purpose, and everywhere the success of cultivation will mainly depend on the efficiency with which the cleaning process is performed. But it must be regarded as a happy provision, that, while the farmer is engaged in contending with these perpetual enemies, he is at the same time producing another important result of tillage,—the stirring and comminution of the soil, and the admission of the air under ground.

These are the general uses and effects of tillage. The various means by which the mechanical operations are performed constitute the most important branch of practical agriculture.

Agriculture is an economical art, involving not only the knowledge of certain works to be performed, but of the modes of performing these works with the greatest economy of time, labour, and capital. The end of all tillage is to produce; but the production must be effected with the due husbandry of means, otherwise the result will be unprofitable. It is not enough to keep the farm rich, dry, and clean, or even to raise abundant crops. These purposes a profuse expenditure may effect, with little skill. The works must be performed, and the crops produced, under the necessary condition of preserving the due balance between the expenditure and the return, otherwise the farming will be bad. A farm may be likened to a machine, in which all the parts must be so adjusted, that they shall move in harmony together, and contribute to a common end with the least expenditure of power. The art of dividing and economising the labour of the farm, of rendering all the labours of the season subservient to the ends proposed, of giving the due degree of culture without exceeding it, and of ap-

plying the resources of the farm to the purposes to be accomplished with the least waste, is a knowledge essential to the farmer, and may be said to form the very foundation of agriculture as a practical art.

It appears to be the opinion of many, that, in order to make a man a farmer, he must be instructed in chemistry, physiology, botany, natural philosophy, and other branches of natural and physical science. Universal experience is opposed to this opinion. The farmer must learn to perform the various labours of the farm, and that under the conditions necessary to secure a due return. But this species of knowledge is purely agricultural,—is not derived from other branches of knowledge,—and is as much within the province of agriculture, as the manual operations of the laboratory are within the province of chemistry, or as the study of the forms of plants is within the province of botany. If the farmer is deficient in this kind of knowledge, all the others will avail him nothing, as a farmer; and possessing it, he may be a skilful and successful agriculturist, although his opportunities may not have extended to a study of the sciences.

It is highly to be desired that the youthful farmer should improve himself in useful or liberal knowledge to the utmost degree which his opportunities will allow. This will make him a more enlightened and unprejudiced man, although it may not, perhaps, enable him to make more money,—will render him better able to follow the progress of future discovery, and to contribute his share to it,—and will connect the business of common life with a higher class of thoughts and feelings. It is impossible, in truth, to value too highly the advantages of educating the rising race of farmers well. But let it be remembered, that the study of the sciences is itself the occupation of long labour; that our youth, and especially our agricultural youth, are called to perform the active duties of life almost before the years of boyhood are expired, and must be early and laboriously engaged in the pursuits proper to their profession in order that they may succeed in it. It is well, indeed, when opportunity is afforded, in any case, to the young farmer to become a botanist, a geologist, a chemist, a natural phi-

losopher; but how small must be the number that can thus employ themselves! and even if they could, their success as farmers would depend, not on their scientific, but on their agricultural knowledge. It were well if the usual branches of education in this country could be so extended as to give as much knowledge of the sciences as the condition of different classes of society would allow; but this is very different from that which many well-meaning people seem to consider necessary for the instruction of the farmer. They would have him to be a botanist, a chemist, a geologist, and so forth, in a degree which few even of the most opulent classes of society ever arrive at. Botany is a captivating pursuit to those who are attached to it; but it is not necessary that the farmer shall learn the names of some fifty thousand plants in order that he may cultivate a dozen. Chemistry is one of the most interesting branches of physical inquiry; but it is not requisite, for any use to which the farmer can apply it, that he shall devote years to the pursuits of the laboratory. Geology is a branch of study in a high degree interesting; but it is not indispensable that the farmer shall make himself acquainted with a class of subjects which, when known, will not make him a better farmer. All the tools and machines of the farmer are constructed on mechanical principles; but experience does not shew that the farmer must be acquainted with mechanical philosophy in order that he may know the use of the plough, the harrow, and other implements of the farm. These remarks are not designed to undervalue the advantages of knowledge to the farmer, or to any one engaged in the common pursuits of life; but to point out the mistakes into which persons unacquainted with practice are apt to fall with regard to such subjects, and to correct the error of repelling men from a useful and necessary occupation, by holding out, as requisite for it, kinds and degrees of knowledge which are unattainable by the great mass of those who must cultivate the soil, and improve the country.

Agriculture is in nothing exempt from the analogy presented by the other useful arts. There may be said to be two periods in its history, in one of which experience is the foundation of the art; another, in which the application is made to it of principles de-

rived from other branches of knowledge. There is no period indeed so rude, in which men do not seek to trace effects back to causes, and reason on what they see and do ; but when the sciences are cultivated, a higher order of investigation is brought to the elucidation even of the humbler arts. We may believe that this period of agriculture is now arrived, and that knowledge derived from the sciences, may, from time to time, throw light on the paths of practice, and, by the explanation of principles, conduct to easier means of arriving at results. Admitting the full force of these conclusions, and the hopes that may be founded upon them, we must be careful that we do not neglect the really useful and practicable for what may never be realized in the manner aimed at,—that we do not confound the actual means at our command of cultivating and improving agriculture with theories of the closet.

Agriculture, it has been said, involves a species of knowledge proper to itself. The business of the laboratory is essentially distinct from that of the fields ; and the most perfect knowledge of the one will not give the knowledge required for the other. It is the province of the chemist to pursue his own studies with a reference to the discovery of truth as the end and reward of his laborious pursuits. When he arrives at conclusions which may be useful in agriculture, he renders the highest service to the art which he can render, by communicating the results to the practical man ; and these, when put to the test of practice, and found to be good, will come within the domain of agriculture. Before this, they are within the domain of chemistry and not of agriculture ; and it is a mixing of subjects to confound the disquisitions of the chemist with the practice of the farmer. It is absurd to require a farmer to farm on a system of chemical experiments. A farmer cannot farm aright on a system of experiments of any kind. He must farm on the basis of experience already acquired ; and experiments must be the exception, and not the rule, of a well-ordered farm. In like manner the vegetable physiologist may pursue his own interesting inquiries as a branch of science, communicating results when they are arrived at, but he should be careful how he counsels the farmer to farm upon a system of theories of vegetation, how-

ever well established they may seem. Such theories may be of high interest in themselves, and yet be of little value in the practice of the farmer. They may be mere opinions formed in the laboratory and the closet, without any knowledge of the business of the fields, or of the modes by which agriculture can be cultivated as a branch of industry. Let us turn to countries where theories of vegetation have been little heard of, and we shall yet find the art of husbandry in a high state of advancement. In the Netherlands, the surface of the country is like a garden; and every available source has been resorted to for rendering it fertile by the industrious inhabitants. In the north of England and a part of Scotland, a system of agriculture has been established which has multiplied the resources of the country in a vast degree; yet, in the forming and perfecting of this system, theories of vegetation have had no share. If we turn to the sister art of gardening, which is the child of experiment in every country, we shall find that it has been perfected without the aid of those researches which many hold to be necessary for the guidance of the farmer.

The Chemistry of Organic Bodies has, within our own times, been cultivated with vast labour and success; but what is the information which this branch of science has as yet communicated to the practical farmer? The latest and the highest authority is an illustrious chemist of Germany, M. Liebig, who has given us, in a work designed for agriculturists, his opinions, discoveries, and conclusions. He informs us, that ammonia is of all the elements of vegetable food the most important, and that this body, with the carbon which enters into the substance of plants, is chiefly derived from the air; that it is the mineral constituents of the earth which are chiefly to be regarded by the farmer as promoting the growth of his plants; that substances which most chemists until now have pronounced to be the very essence of fertility in soils and manures, do not exist in them at all; and, in short, that all previous theories of vegetation which do not accord with these ideas are erroneous. Now, the opinions of the learned chemist may be right, or they may be wrong; but how is the farmer to decide between rival theories of this kind? Of what utility are such discussions

to him, or what dependence ought he to place upon conclusions, when the highest authorities are at variance with respect to first principles? It is manifest that the subjects themselves are without the province of agriculture. They fall within another branch of inquiry altogether, and are nearly as useless to farmers as would have been the dreams of alchymists. The same eminent chemist makes light of experience, which the farmer knows he can never do with safety. He informs us that it is a great discovery that one of the best manures for land is burnt straw; while the farmer who understands his business will use his straw for the purposes for which it is necessary to him, in place of burning it. He leads us to believe, that we may by and bye hope to get rid of farm-yard manure, which does not contain a sufficient quantity of ammonia, and which promotes the growth of weeds; and he encourages us to hope, that, in place of the present cumbrous apparatus of farm-yards and muck-wains, the farmer will have a laboratory in his fields to manufacture silicates and phosphates!

Now, such a mode of applying science to the improvement of an art is in itself unphilosophical. It is not by such speculations that chemistry has been rendered serviceable to any one art, or branch of art, to which it has been yet applied; and if ever it is to become the handmaid of agriculture, it is manifest that it must be by very different means from the promulgation of reveries of this kind. If chemists can believe that such theories fall within the province of their own science, let them confine them to it, but do not let them seek to extend them to a pursuit in which they are worse than useless. The practical farmer who would be silly enough to act upon theories of this kind, might be ruined in a single season, and, at the least, would be diverted from the course which might be useful to himself, into speculations which, in his hands, would be idle and profitless. But the more general effect to be apprehended from these misapplied speculations is to bring science itself into contempt with practical men, and to retard that application of it to agriculture which it is so much wished to promote.

It is greatly to be desired that men of science shall be invited

and induced to make the application of their acquired knowledge to the useful arts; but if this is to be done with any useful effect in the case of agriculture, it must be with just views of the ends to be arrived at, and of the means of attaining them. Agriculture, it should be kept in mind, is based on a longer series of observations than any art known to the human race, and it is idle to disregard experience in an art which is founded upon it. We sometimes hear the farmer termed obstinate and ignorant, because he will not act on new opinions, and abandon the only track in which he can travel with safety; but the obstinacy is sometimes a necessary adherence to what cannot be prudently departed from, and the ignorance generally lies with the instructor, who is himself destitute of that practical knowledge which can enable him to determine whether, and under what conditions, his principles can be applied. We sometimes hear of Scientific agriculture, as contradistinguished from that which is pursued by the farmer. Few terms are more abused in the present day than the term Science; but if it is to be applied to the arts at all, it is difficult to see why it should be applied to the agricultural system of a chemist and vegetable physiologist, and withheld from that of a skilful farmer. Of all the cultivators of science, the chemist has the least right to make such a distinction. The science of the chemist is itself essentially experimental, and the experiments of the farmer, although performed in a different manner, and with a relation to different results, are not less the basis of a series of deductions; and these deductions form as properly the science of the farmer, as the others form the science of the chemist.

Agriculture involving a class of considerations proper to itself, the knowledge of them is necessary to the farmer; and his success, all other things being alike, will mainly depend on the degree in which he possesses this knowledge, and the skill and diligence with which he applies it to use. The full knowledge of the details of practice can only be obtained by experience and observation, and is most quickly and easily acquired in the fields. Instruction, however, if rightly given, may greatly aid the acquisition of practical knowledge, and save the labour of him who enters upon

the study for the first time. The operations of the farm, though all tending to simple results, are yet very complicated with respect to the times and modes of performing them. Certain labours are proper to certain seasons, and at all times are modified by the nature of the weather and other contingencies. There generally, too, elapses a considerable period between the first operation and the final result, so that the chain of consequences is not always clearly observed. From these different causes, there is a peculiarity, and even a difficulty, in the study of agriculture, which is not experienced in the common mechanical arts. The aim of preliminary instruction should be to lessen that difficulty, and direct the attention of the young observer aright. By being made acquainted with the nature of the operations to be performed, and the ends to be arrived at, he will be saved much of that embarrassment which he would otherwise experience, from seeing so many labours carried on, as it were, at the same time and in seeming confusion.

IV. IMPLEMENTS OF THE FARM.

In order to understand the manner of performing the labours of the farm, we should possess a certain knowledge of the mechanical agents to be employed. It is rarely, indeed, necessary that the farmer shall himself be able to construct machines, because in most countries where the arts are cultivated, there will be a class of artisans who can supply to him the common instruments of which he stands in need. But yet it is well that he be acquainted with the general principles upon which his machines should be constructed, and so be able to supply, if necessary, the want of skill in the workman.

The machines, or implements of the farm, may be divided into classes, according to the purposes to which they are to be applied :—

1. Implements of Preparatory Tillage, so called from being the instruments used in preparing the land for the plants to be cultivated—
   (1.) The Plough.
   (2.) The Harrow.
   (3.) The Grubber.
   (4.) The Roller.
2. Machines for Sowing—
   (1.) Corn in rows.
   (2.) Corn and Grass-seeds broadcast.
   (3.) The seeds of the Bean and Pea.
   (4.) The Smaller Seeds in rows.
3. Implements for Hoeing.
   Horse-Hoes, &c.
4. Machines for Thrashing and Winnowing.
   (1.) Thrashing-machine.
   (2.) Winnowing-machine.
5. Implements for preparing food for live-stock.
   (1.) Turnip-slicer.
   (2.) Chaff-cutter, &c.
6. Wheel-Carriages.
   (1.) Single and Double-horse Cart and Waggon.
   (2.) Sparred or Corn-cart.
7. Utensils of the Dairy.
   (1.) Churn.
   (2.) Cheese-press, &c.
8. Implements of Manual Labour, &c.
   Barrows, Forks, Spades, Shovels, &c.

1. Implements of Preparatory Tillage.

(1.) *THE PLOUGH.*

By mean of this instrument the earth is to be turned over to a given depth; and this is to be effected by cutting from the ground successive sods or slices of earth, so that each sod or slice shall

be raised up and turned over, and all the sods or slices laid resting upon one another, in such a manner as that an entire new surface shall be exposed to the atmosphere.

In the following figures, let ABCD represent the end or transverse section, which is assumed to be a right-angled parallelogram, of the slice of earth which is to be turned over.

Fig. 6.

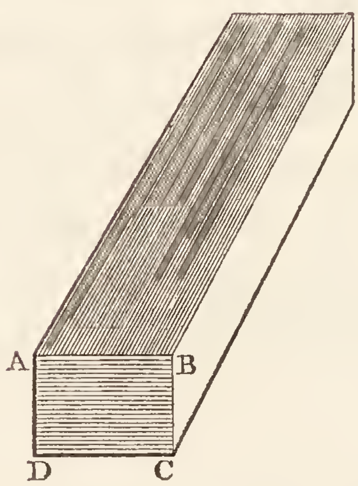


Fig. 7.

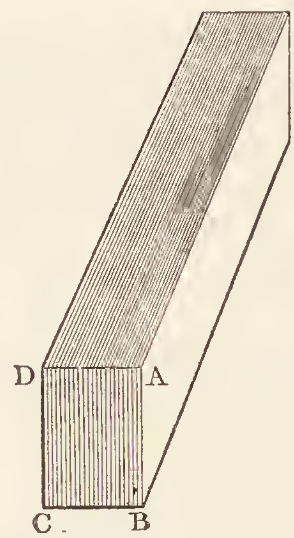
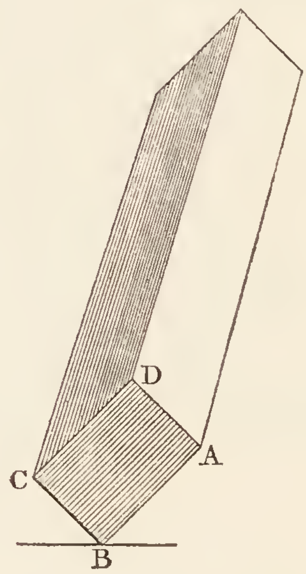


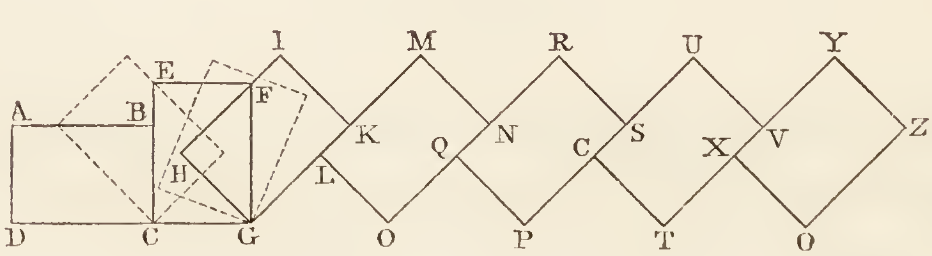
Fig 8.



The slice is first to be raised from the position in which it lies in Fig. 6 ; it is next to be placed in the position shewn in Fig. 7 ; and it is finally to be placed in that represented in Fig. 8.

In the following diagram, let ABCD, corresponding with the same letters in the last figures, represent a transverse section of the slice of earth which is to be turned over. This slice is first to be raised from its horizontal position ABCD, by being turned upon its corner C as a pivot, and placed in the position CEFG, corresponding with that of Fig. 7. It is then to be turned upon its corner G as on a pivot, and laid in the position GHIK, corresponding with that of Fig. 8. In this manner the side DC, which was formerly underneath, will be above, namely, in the po-

Fig. 9.

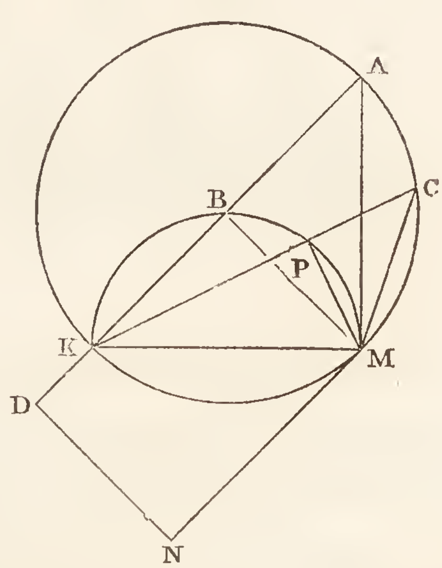


sition HI, and AD will be in the position IK; and if successive slices shall be thus reversed, they will rest upon one another in the manner shewn by the sections of the slices OXYZ, TCUV, PQRS, OLMN, and GHIK, Fig. 9.

The angle of inclination at which these different slices will naturally rest upon one another in the manner shewn in the figure, will depend upon the proportion which the width of the slices bears to their depth; and, that the greatest extent of surface may be exposed to the air, the angle of their inclination must be 45°. In order, therefore, that the slices may be at this angle, the proportion which the width of the slices bears to their depth is to be determined; and this can be done by simple calculation; for it can be shewn that the width of the slice AB being the hypothenuse of an isosceles right-angled triangle, the depth of the slice BC will be one of the sides. Supposing, therefore, the width of the sod AB to be 10 inches, the depth BC will, by calculation, be 7·071 inches.*

* That the maximum of surface will be exposed, when the angle of inclination of the sods is 45°, may be demonstrated thus: Let the right-angled parallelogram DBMN, in the following figure, represent a section of the sod or furrow-slice, BKM being an angle of 45°, and KB being equal to BM. On KM, which is here = BD, as a diameter describe the semicircle KBM, and in that semicircle draw any other triangle KPM, representing a section of a sod having the same width as before, but with the depth PM; then will the two sides KB, BM of the isosceles right-angled triangle KBM be together greater than the two sides KP, PM, of any other right-angled triangle KPM on the same base KM.

Fig. 10.



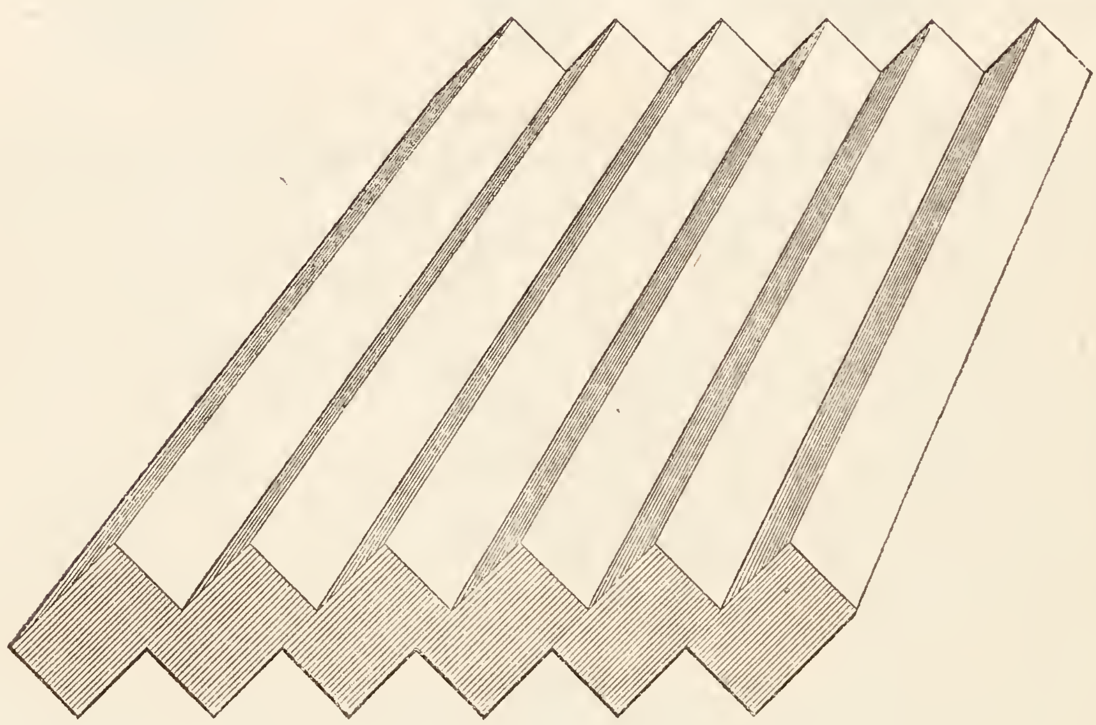
For, produce KB, and make BA = BM; produce also KP, and make PC = PM, and join AM and CM. Then because KBM is the exterior angle of the triangle BAM, it is equal to the sum of the interior and opposite angles BAM and AMB; but BA = BM, therefore the angle BAM = AMB = ½ KBM. In like manner, the angle KCM = ½ KPM. But the angle KBM = KPM, and therefore the angle KAM = KCM. Hence, the segment of a circle upon KM from the centre B will pass through the points C and A; but the diameter KBA is greater than any other straight line KPC, which does not pass through the centre. Hence, since KA = KB + BM, and since KC = KP + PM, it follows that KB + BM is greater than KP + PM.

To determine the ratio which the depth of a sod will bear to its width when

If, then, beginning at one side of a field, we shall cut off a slice of earth, the entire length of this field, and place it in the position OXYZ, Fig. 9, and then cut off a second slice, and place it in the position TCUV, and then a third slice, and place it in the position PQRS, and so on, the various slices will rest upon one another at a given angle, in the manner represented.

A similar operation is to be performed by the plough. Beginning at the right-hand side of the field or ridge to be ploughed, a sod, which we shall now call a furrow-slice, is to be cut from the firm ground, raised up, and turned over. A second furrow-slice is in like manner to be cut from the firm ground, raised up and turned over, and so on. In this manner an entire new surface will be exposed to the atmosphere, and the successive furrow-slices laid resting upon one another, thus:—

Fig. 11.



A well formed plough is that which will perform these operations with the least resistance, with the least risk of injury from the strain or shock of opposing obstacles, and which shall join

the inclination is 45°—Since KBM is an isosceles triangle right-angled at B, $KM^2 = KB^2 + BM^2 = 2\ BM^2$, and consequently $BM = \sqrt{\frac{1}{2} KM^2}$. Hence, suppose KM, the width of the sod, to be 10, then the depth $BM = \sqrt{50} = 7{\cdot}071$ as in the text.

to those properties such simplicity of form as is compatible with its uses.

The plough may be formed partly of wood, and partly of iron. But as, when it is formed wholly of iron, it admits of a somewhat better combination of its parts, the following figures represent it as of this material, certain parts being of malleable iron, and certain parts of cast-iron.

Fig. 12 represents the plough, as seen from the right-hand side, or from that side which is at the right-hand of the ploughman when at work. In this position are seen the two handles A and B, by which it is guided, the mould-board DEHGF, the share HGI, the beam C, and the coulter K.

Fig. 12.

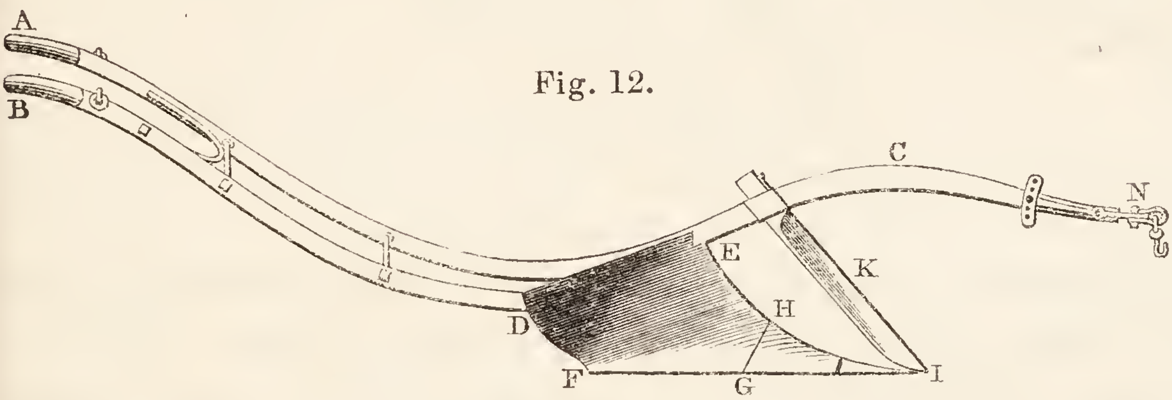


Fig. 13 represents the instrument as seen from the same side, but with the mould-board and share removed.

Here the connexion is shewn of the left handle A with the beam C, of which it forms a continuation, and of the right handle B, with the lower part of the frame-work. The upper ends of these two handles rise to the height of about three feet above the plane of the lower part of the plough. They are to be regarded as levers in the hands of the ploughman, for enabling him to direct the instrument.

Fig. 13.

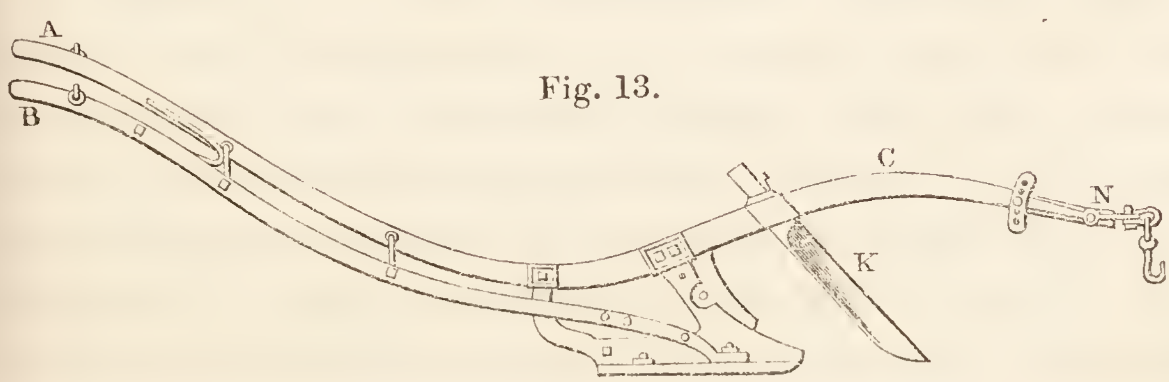
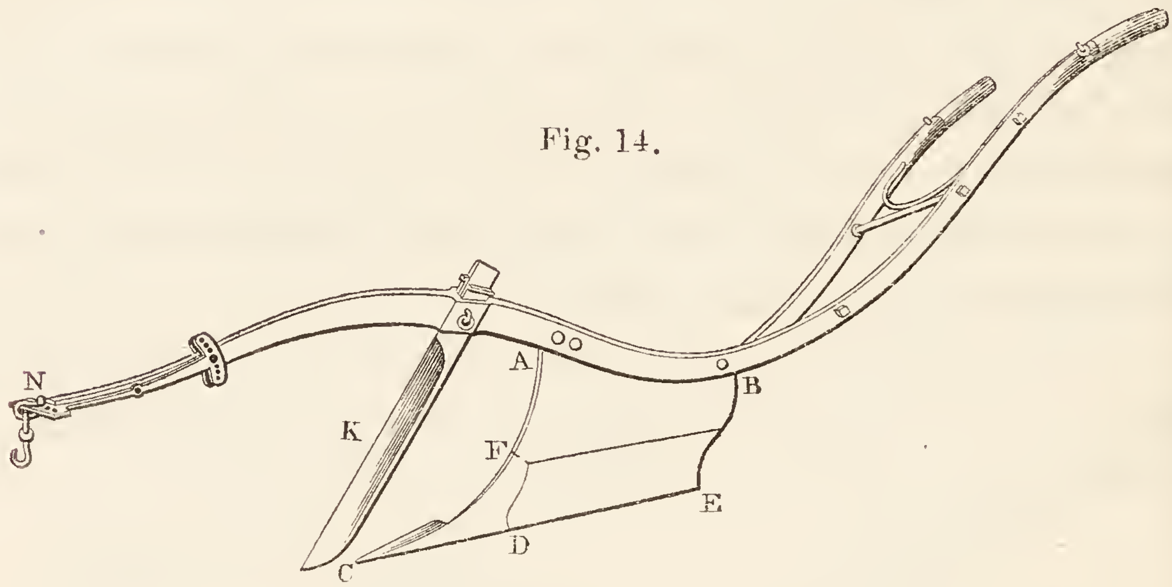


Fig. 14 represents the plough, as seen from the left side, being that side which, in working, is toward the unploughed land. The part AFDEB is a perpendicular plane, formed of plates of iron. The surface of these parts, the left side of the share FCD, and of the coulter K, should be in one plane, and move in a direction parallel to the line of draught.

Fig. 14.



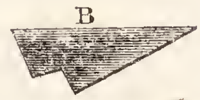
The beam is that part of the plough to which the moving power is attached. Upon the end of the beam is placed a bridle, as it is termed (N, Figs. 12, 13, and 14), to which the point of draught is fixed, and by means of which the line of draught can be elevated or depressed, and moved to the right hand or to the left as may be required. The bridle terminates in a horizontal plate, having holes or notches to which the line of draught is attached, and is moveable round a bolt passing through the beam, by which means the horizontal plate can be raised or lowered. The beam is curved in its form, in order that, being more elevated above the surface of the ground, it may be less impeded by stubble and other matters upon the surface.

In the beam is fixed the coulter K (Figs. 12, 13, and 14). The use of this part is to cut the sod vertically from the firm ground, previous to its being raised up and turned over. Its position is inclined forward as in the figure, so that when it encounters stones or other substances under ground, it may tend to force them upwards. The inclination of its fore-part to the plane of the plough's sole, may be from 45° to 55°, or more. Its right side should be

welded with steel, on account of the greater attrition to which that part is subjected.

The share, Fig. 15, is made to be taken off, that it may be sharpened when necessary. It is formed with a wing or projecting edge to the right-hand side, which is frequently laid with steel, to preserve the sharpness of the cutting edge. The use of the wing is to cut the under part of the furrow-slice, previous to its being raised upon the mould-board. It is usually made from 5 to 6 inches, measured from B to A.

Fig. 15.

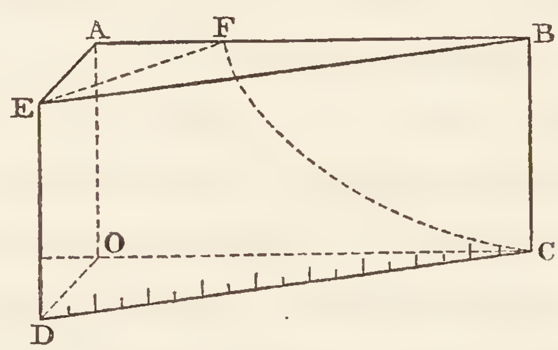


The share is formed of malleable, and the mould-board of cast iron. The two parts combined form a curved surface, which, beginning at the point of the share I, Fig. 12, gradually rises from the horizontal plane, until it is vertical at F, at which point, accordingly, a perpendicular line would touch it from top to bottom. The surface then continues to incline in a uniform manner to the right-hand side, until, at its extreme point D, it inclines over to that side at the angle at which the furrow-slice is to be laid. The whole right-hand side of the plough, therefore, consisting of the share and mould-board, forms the surface of a curved wedge, which, from the point of the share where it is horizontal, becomes gradually more and more upright, till it is perpendicular, and then continues inclining by a gradual curve to the right-hand side, until it has formed with that side the angle at which we wish the furrow-slice to be laid. The wedge thus formed being insinuated beneath the furrow-slice and pushed forward, gradually raises it to a perpendicular position, and then, by acting upon the upper part of it, presses it over into the position in which it is to lie.

That we may better comprehend the nature of the wedge which the plough forms, let ABCDEO, Fig. 16, represent a wedge, one of whose sides, ABCO, placed perpendicularly, moves in the line of the plough's motion, and, consequently, corresponds with the left-hand side of the plough, and whose other side, EBCD, is applied obliquely to the furrow-slice to be moved, and whose width behind, DO, is equal to the width of the sod to be moved. Such a wedge, moved forward in the ground, is calculated to move the

furrow-slice to the right-hand side; but it is not calculated to raise it up. But let the lower part of this wedge, DC, be supposed divided into a certain number of equal parts, as ninety, then, beginning at the point C, corresponding with the point of the share, let all the upper part of the wedge from the edge CD backwards, be supposed to be cut or scooped away in such a manner as that, when we measure the angle which the surface of this new wedge forms with its base, we shall find that at the first equal part or division, the inclination of the surface to the base is 1°, at the second 2°, at the fifth 5°, at the tenth 10°, and so on to the ninetieth at D, where it is 90°, or perpendicular. In this manner we shall have formed a new wedge EAFCDO, whose face EFCD, becomes gradually more and more upright from the point C to the point D, where it is wholly upright, and so forms a uniformly curved surface from the point to the extremity. A wedge thus formed, it is apparent, is calculated to raise the furrow-slice in a uniform manner from its horizontal to its perpendicular position, and is resolvable into two planes, one of which acts in elevating the sod, and the other in moving it to the side.

Fig. 16.



There yet remains, however, the further operation of pressing over the furrow-slice into the position in which it is to be ultimately laid. Now this we may suppose to be effected by lengthening out our wedge behind from DE backwards, and continuing it with a gradual curvature to the right-hand side, in such a manner as that after having passed the perpendicular at DE, it shall incline more and more to the right-hand side, until, at its termination, it shall have formed an angle with the surface on this side of 45°. In this manner the surface of the wedge will represent the right-

hand side of the mould-board and share, beginning at a point, rising by a gradual slope from the horizontal plane to the vertical position, and then gradually inclining towards the right-hand side, until it forms with that side the angle required to press the sod into its position.

It is to be observed, however, that when the furrow-slice has reached its perpendicular position at D, it begins to be turned upon a new pivot, as seen in Fig. 9, so that there is a slight change in the theoretical curvature of the wedge at that point; and further, it is to be observed, that when it has reached this perpendicular position, it must be no further acted upon by the mould-board below, for which reason all the lower part of the prolonged wedge must be cut away in the manner shewn in the different figures of the mould-boards.

This description will shew the general nature of the wedge formed by the share and mould-board, by the action of which, it has been seen, a slice or sod of given dimensions is cut from the firm ground, and is gradually raised up, and conveyed by the hinder part of the mould-board into the position in which it is required to lie. In considering the nature of this wedge, we may omit the consideration of the thin wing of the share, which is not an indispensable adjunct of the plough, and the surface of which is a mere continuation of that of the wedge which forms the rest of the share.

The surface of the share and mould-board has been described as uniform; but in practice it is not to be made entirely uniform, on account of the resistance of the earth being greater at certain parts of the ascent of the furrow-slice than at others. Thus, towards the point of the share, the resistance to be overcome is greater than at the extremity of the mould-board, and, therefore, the wedge is made more acute at that part than behind.

A curved surface, such as has been described, may be easily formed by various means. These, however, need not be described; neither is it necessary to explain in detail the several corrections to be made on the form of the parts, much less the changes which the judgment or fancy of different artisans leads them to make. It must suffice here, that the general form of the instru-

ment is understood, which will be easy when the actual plough is seen.

The perpendicular height of the mould-board may be 16 inches, being that height which is sufficient to prevent the loose earth from being thrown over it when the plough is at work. The width of the plough below, measured from the left-hand side to the point of the mould-board F, Fig. 12, where it is begun to be cut away, and where its surface is perpendicular, should be just equal to the width of the sod, and which has been here assumed to be 10 inches; but which most makers of ploughs assume to be 9 inches. The lower part of the plough, from the point of the share C to the heel E, Fig. 14, should be of that length which is sufficient to give steadiness to the motion of the instrument, and need in no case exceed 36 inches even in the largest ploughs. It is the error in the case of rude ploughs that these parts are formed unnecessarily large, and especially the width below, by which means the resistance is uselessly increased.

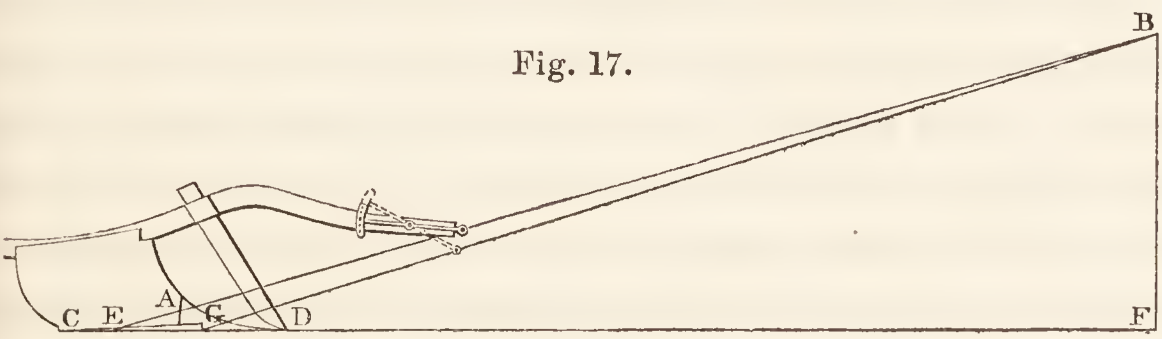
An essential property of the plough is, that it shall move in the earth with a steady motion; and the giving to it the form and combination of parts necessary for that purpose is one of the main difficulties attending its construction.

Were it ascertained by experiment on the plough when at work, at a given depth of furrow, and in a soil of a given texture, that a cord attached to any point on the surface of the wedge, as A, Fig. 17, and drawn in the oblique direction AB, would so pull forward the plough, that it should press uniformly upon the earth at all points from C to D, so that the share should neither tend to point upwards nor downwards, but should move horizontally forward, then it is to some part of this line that the moving power may be applied; and further, it is known from the principles of mechanics, that it matters not, in so far as regards the force exerted, to what precise part of this line the power is applied. Now, without entering into any mathematical investigation of the principles upon which this line is to be determined, it is to be observed, that, in a well-made plough, formed on the principles pointed out, this line, drawn from the usual point of

attachment of the draught on the collars of the working cattle, will intersect the surface formed by the share and mould-board at about half the assumed width of the sod from the plane of the land-side, and at about half the depth of the sod from the plane of the lower side or sole. If this line be extended, it will intersect the sole itself at some point, as E, behind the setting on of the share, and to the right of the plane of the left side of the instrument. It is designed to pass through the centre of resistance of the plough when at work, and will intersect the sole at a greater or less distance from the share, as the line of traction is more or less oblique.

Now, knowing the height at which the point of draught is to be attached to the shoulders of the working cattle, let us suppose 4 feet, and the distance from the point of the share at which the animals of draught can be conveniently yoked, let us suppose 12 feet, then laying off DF 12 feet, and FB 4 feet, and drawing BE, it follows that the point at the end of the beam to which the draught is attached, may be placed in any part of the line BE. So that whatever be the length which we shall give to the beam, the line in question will denote the end of it, or the point to which the draught is to be attached.

Fig. 17.



The more horizontally we can place the line of traction EB, the greater is the proportion of the motive power which is exerted in drawing the plough forward; but we are limited in our power of giving a less oblique position to the line of draught by the necessity of keeping the traces of a convenient length. And further, when we have determined the line EB from considerations of convenience, still the angle which it forms with the surface is not, as can be shewn, constant, but varies with the depth ploughed,

and the tenacity of the soil. That the instrument may suit itself to these variations, as well as that any defects in the form of its parts may be counteracted, and that the line of draught may be placed in that position which is required to pull forward the plough, without there being any tendency in the share to sink into the ground or rise out of it, the bridle is fixed at the end of the beam, so as to elevate or depress the line of draught, as may be required. Should the plough, for example, tend to go deeper into the earth, the line of draught is to be lowered by means of the bridle, so that it shall form a greater angle BGF; the effect of which will be to counteract the tendency which the plough has to go deeper. The same effect will be produced by shortening the traces by which the horses are attached to the draught, and thus increasing the angle. In like manner, by means of the bridle, the point of draught can be shifted to the right or to the left. If the point of the share tends to turn to the left hand into the firm ground, the line of draught is shifted more to the left, and if to the right hand, it is shifted more to the right. This adjusting of the plough's motion is easy, and is performed by the ploughman, until he feels that the plough continues to *swim fair*, to use his own technical language; that is, until he feels, which he does at once, that it continues to move horizontally forward, without any tendency to turn to the right or left, or to rise from the earth, or to sink into it. A well-constructed plough of this kind, therefore, does not require wheels or other devices to steady its motion; the effect being produced by the right adaptation of its parts to one another, and by altering the direction of the line of draught.

It is difficult, however, to form a plough, in which all the parts shall be so adjusted as that it shall move steadily forward in the true line of motion. In ploughs, as they are commonly constructed, there is a tendency in the share to turn to the right-hand side, or away from the unploughed land, and to turn upwards, especially when encountered by obstacles, and so to throw the plough out of the ground. To counteract these tendencies, it is common to cause

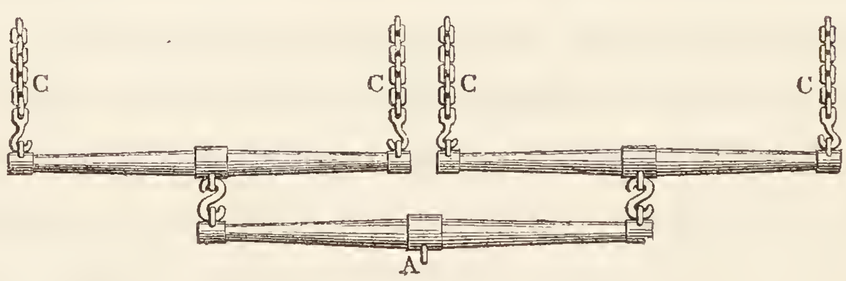
the share to point a little to the land-side, as well as a little downwards, so as to give the instrument a firmer hold of the ground. These corrections, within certain limits, may be unavoidable even in the most carefully constructed ploughs ; but it is evident, that this counteracting of one tendency by another is in itself a defect, increasing the general resistance; and that the more nearly the disposition of the parts accords with the true form, the more perfect, *cæteris paribus*, is the construction of the instrument. Another practice is to point the coulter to the left hand, even considerably beyond the plane of the land-side of the share and mould-board. This, to every one who will consider the nature of the wedge employed in cutting and elevating the sod, will be seen to be a defect. If the plough is to be held vertically, the position of the coulter must be vertical, and if the sod is to be cut square, like a brick, that is, having the section rectangular, it is plain that the coulter must be placed at right angles to the plane of the lower side or sole of the share ; and if the left side of the coulter is not on the plane of the land-side of the share and mould-board, the draught is increased by presenting a greater number of points of resistance to the sod.

The undoubted honour of having perfected this species of plough belongs to JAMES SMALL, an ingenious mechanic of Scotland, who, by observing the defects of the former ploughs, succeeded in forming an instrument which may be used in every part of the world, and which has added millions to the wealth of his native country. A treatise by him remains to shew the steps by which he arrived at the discovery of the principles on which a good plough may be constructed. Numerous variations, many of them proper, have been subsequently made in the form and disposition of the different parts, but the essential principle of construction as taught by Small, is observed. The ploughs of this kind are more or less perfect, according to the skill and experience of the artisans who construct them. They are for the most part efficient in a high degree. In the countries where they are used they are drawn by two horses yoked abreast, and are capable of performing, by easy

labour to the animals of draught, almost every species of tillage which the plough is required to perform.*

Although the animal of draught employed in this species of plough is the horse, as being better suited than the ox to the variety of labours in which the husbandman of this country employs his working-cattle, and to the despatch which he deems essential in all his operations, yet it does not follow that the horse is to be preferred to the ox in all countries and in all cases. In many countries the ox may still, on account of his more easy means of support and other qualities, be advantageously used. But whether the ox or the horse be employed it matters not, in so far as it regards the construction of the simple and efficient machine which has been described. It is equally suited to either species of draught, and only requires that the height of the beam shall be varied a little to suit the animals employed, and the manner in which they are attached to the yoke. When horses are used, they are attached by an apparatus of swing-trees, as in Fig. 18, to the bridle at the beam by a hook at A. These swing-trees being connected together, each horse pulls against the collar of his fellow, so that each must exert an equal force in pulling. They are attached by chains or traces, CC, to their respective swing-trees.

Fig. 18.

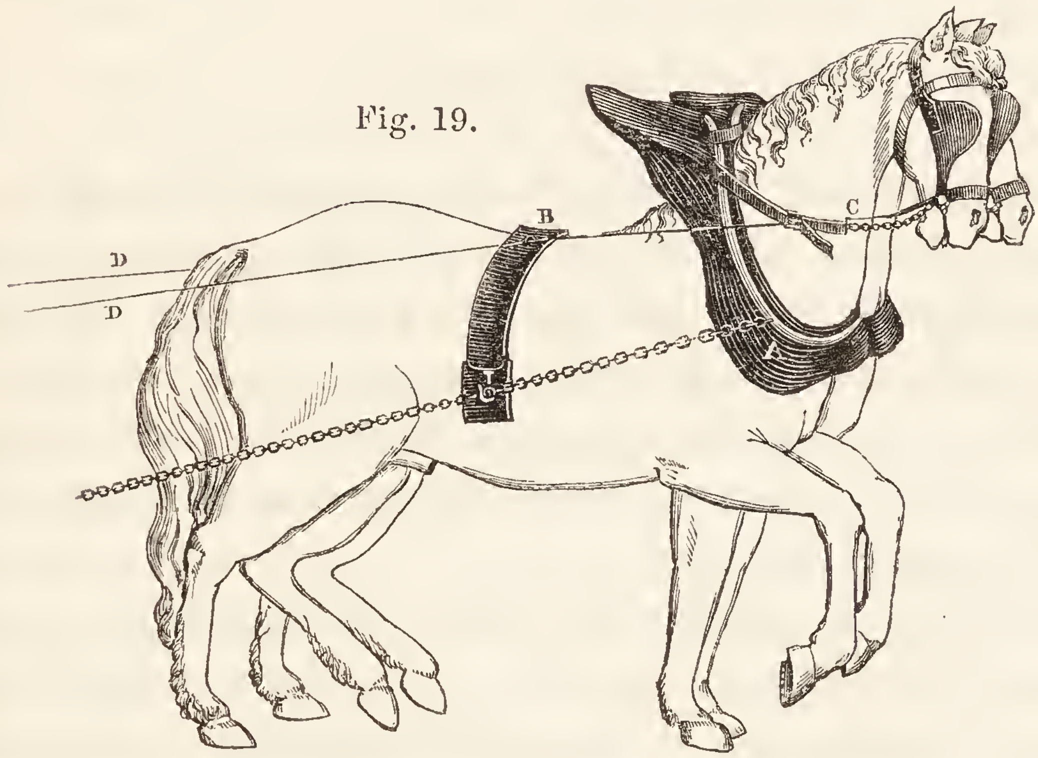


The chains or traces by which the horses are yoked, are fixed to hooks on the collar as at A, Fig. 19. The traces are prevented from falling down by a broad belt of leather B, fastened to the traces, and passing over the back of the horse. Each horse has

* A description of the plough of Small, with an explanation of the principle of its construction, was many years ago communicated by me to the Conseil Royal d'Agriculture de France, and, with accounts of the harrow, grubber, and other implements, was afterwards published in the Quarterly Journal of Agriculture.

a snaffle-bridle C, and a cord is attached to the inner ring of each bridle, and to the trace of the opposite horse, for the purpose of keeping the horses together. Long reins DD, are attached one to the outer ring of each bridle, pass through rings on the belts of the leather B, and are looped to each handle of the plough. With these, assisted by the voice, the ploughman directs the horses, and uses the reins instead of a whip, when necessary, to urge the animals forward.

Fig. 19.



Resting between the handles of the plough is a little spade, Fig. 20, with which the ploughman removes the mud that may be collected on the mould-board, or any substance that may be collected between the beam and the coulter, or between the beam and the forepart of the mould-board. It is convenient, too, to have a little hammer appended to the plough, with a key at one end, to be used when occasion requires.

Fig. 20.

Wheels, in many ploughs, are attached to the end of the beam. It is believed that it can be shewn from a consideration of the mechanism of the parts, that the labour of draught is not lessened

by this device; yet the plough with wheels is more steady in its motion, and more easily managed, and thus may be guided by a less skilful workman. But the simpler instrument, when the ploughmen are instructed in the use of it, will be found to be greatly more efficient in practice.

The manner of ploughing a given piece of ground, as a field or a ridge, will be described under the head, Simple Operations of Tillage.

(2.) *THE HARROW.*

This instrument consists of a frame of wood or iron, in which a certain number of teeth are fixed, which are pressed into the ground by their own weight and that of the frame. The instrument is intended to pulverize the ground which has been acted upon by the plough, to disengage from it the roots and other substances which it may contain, and to cover the seeds of corn and other cultivated plants.

The harrow is greatly more simple in its form than the plough. It is even an imperfect machine, in any form of which we can construct it; yet it is of great utility in tillage, and should receive all those mechanical improvements of which its nature will admit.

The harrow performing its operation by means of a certain number of teeth moved forward in the ground, and pressed downwards by their own weight and that of the frame in which they are fixed, the first questions that occur in investigating the principles of its construction are, the form that should be given to those teeth, and the manner in which they should be disposed in the surmounting frame. Were it the end, in harrowing, solely to drag up the roots of plants and other substances from the ground, the best form, perhaps, that could be given to the teeth would be that of a thin wedge, tapering to the point, like the coulter of a plough, and, like it, inclining forward. But although this construction might be the best calculated for tearing up roots and other substances beneath the surface, it would not be so well

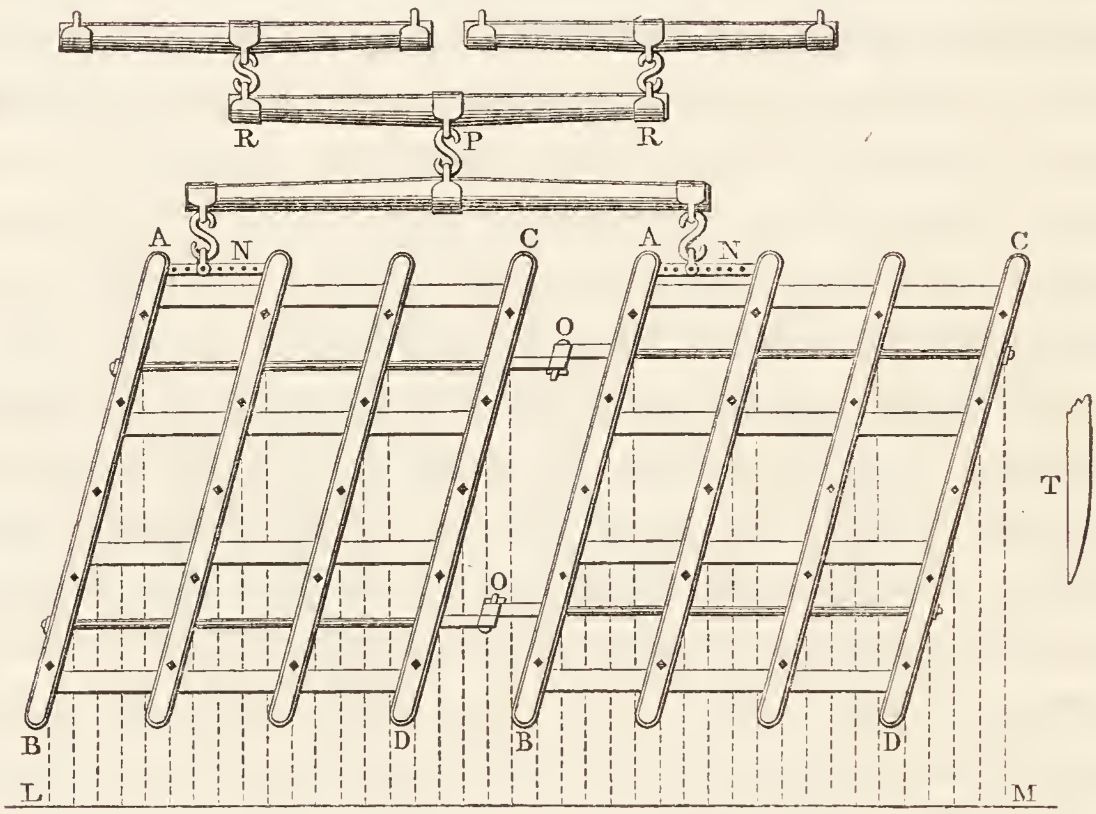
fitted for covering seeds, and for breaking and pulverizing the ground, as when a broader surface was presented to the earth, and a greater movement given to its particles. The wedge for this purpose should be broad rather than thin. In order, therefore, to adapt the form of the teeth to this purpose, to the strength necessary to be given to them, and to the lateral or shaking motion to which they are subjected in passing over rough ground, as well as to their forward motion,—it is conceived that the best form of them will be when their horizontal section is a square, whose diagonal is moved forward in the line of the harrow's motion; while they should gradually taper to a point, the fore-part being kept straight, as in T, Fig. 21.

With regard to the distribution of the teeth in the frame of the harrow, they should not be placed too closely together, for then they would be too much impeded by the obstacles opposed to them. Further, they should be so disposed with relation to one another, as that one part of the instrument shall not be more interrupted than another: Again, their number should not be too great, because then their power to penetrate into the ground will be diminished, unless the weight of the whole instrument shall be increased in a corresponding degree: And, lastly, their length should not be greater than is necessary, because they will not on that account penetrate more deeply into the ground, unless the whole weight is also increased, and because this increase of length will give a greater power to the teeth, when encountered by obstacles, to split the frame in which they are fixed.

The harrows represented in Fig. 21, of which the frame is of wood and the teeth of iron, are formed with a regard to these general principles. They are connected together in pairs by hinges. They consist each of four bars of wood, AB, CD, &c., which are joined together by an equal number of cross bars of smaller dimensions, mortised through them. The larger bars are placed oblique to the smaller bars, and to the line of the harrow's motion, and the teeth are inserted into them at equal distances from one another. This inclination is made to be such, that perpendiculars from each of the teeth falling upon a line LM,

drawn at right angles to the harrow's motion, shall divide the space between each bar into equal parts, so that the various teeth, when the instrument is moved forward, shall indent, at equal distances, the surface of the ground over which they pass.

Fig. 21.



The number of teeth in each harrow is 20, 5 being inserted in each of the larger bars. When two harrows, therefore, are employed together, the surface of the ground from L to M is indented by 40 teeth, impressing the ground at equal distances, and covering the space of about 9 feet. The teeth may project below the under surface of the frame 8 inches or more. The teeth are often inserted into the frame with a little inclination forward; but this deviation from the perpendicular is not necessary, and renders the harrow more apt to be impeded by the weeds or other substances collected in the angle between the teeth and the frame. The teeth are fixed in the bars by boring holes with an auger of about $\frac{3}{4}$ of an inch in diameter, and then driving them firmly through. The teeth, when thus driven into the bars, will be retained with sufficient firmness. The best of the common kinds of wood for the bars, as being the least liable to split, is ash.

The iron rods which terminate in the hinges O, O, may pass

through the framework, to give it greater strength. These rods keep the harrows at the distance required, and the hinges admit of either harrow rising or falling, according to the inequalities of the surface. When thus joined, the harrows are drawn by two horses guided by reins, the driver walking behind, so as to be prepared to lift up either harrow when choked by weeds, or otherwise interrupted.

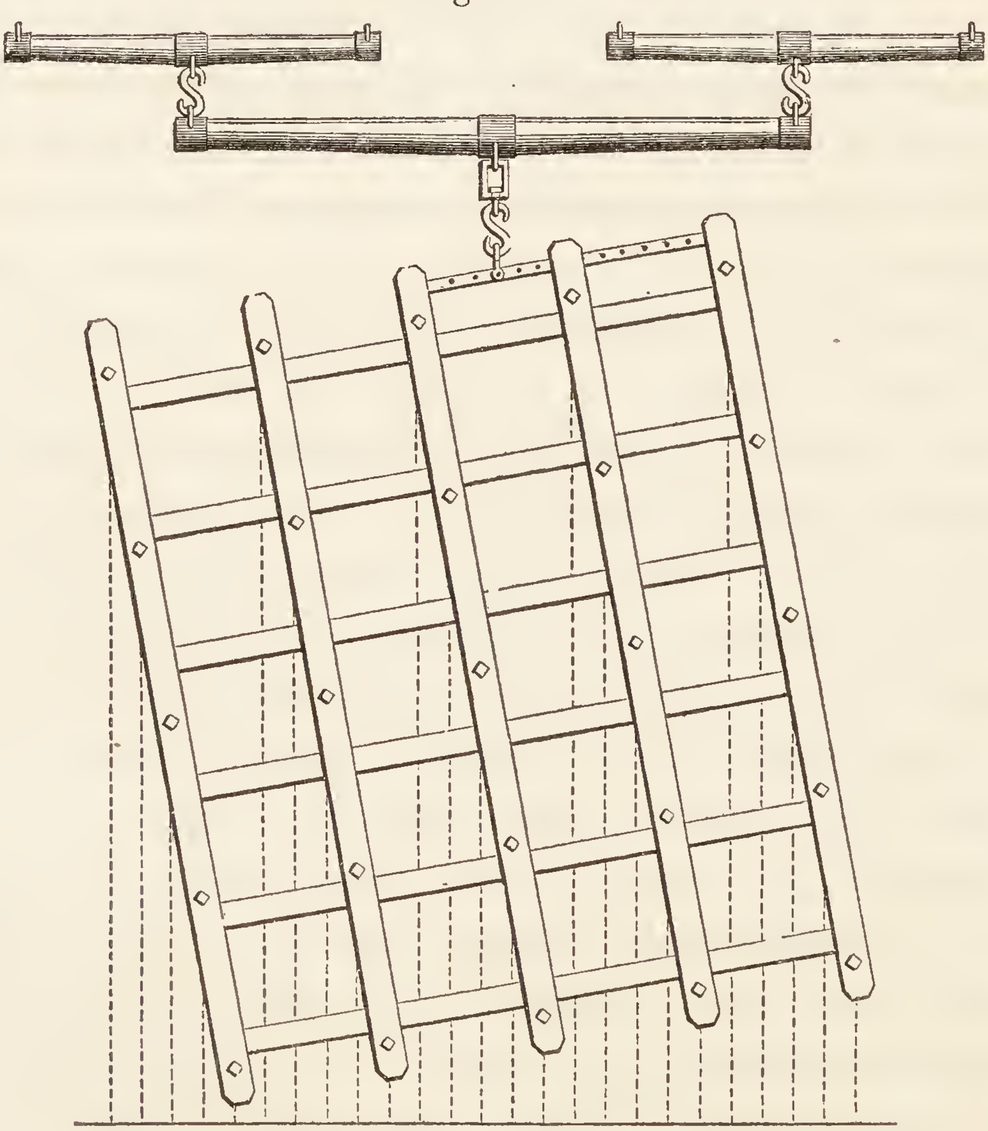
The method of attaching the animals of draught will be explained by the apparatus of swing-trees shewn in the figure, by means of which each animal must exert an equal force in pulling. There are plates of iron N, N, passing through the left-hand bars of each harrow. These plates have a few holes in them, so that the line of draught may be shifted to the right or left, as may be required. The staple P upon the swing-tree RR being the point to which the moving power of the harrow is attached, it is important to ascertain its proper position.

Were a perpendicular to be let fall from P upon the line LM, the point of intersection would be in the middle of the entire breadth covered by the harrows, in order that an equal number of teeth should be on each side of the line of traction. But the larger bars being placed oblique to the line of the harrow's motion, when any obstacle raised above the surface of the ground strikes one of these bars, it tends to press it to the right-hand side. And as there are 8 bars of this kind, and these of considerable length, it will appear that, in ground where there is any great unevenness of surface, there will be a constant succession of strokes, forming a strong lateral pressure on the left side of the several bars. But the staple P being nearly fixed in its position, while the harrows may be moved round, the effect of this lateral pressure is to turn the whole harrows on P as a pivot from left to right. In practice, accordingly, there is found to be a constant tendency in the harrows of this construction to swing round from left to right, and this often to so great a degree in very rough ground, as to place the larger bars parallel to the line of motion, thus causing all the teeth in the same bar to follow the same track. Hence the point P ought not to be precisely in the middle of the space covered by

the harrows, but placed somewhat to the left hand, in order that so great a number of teeth may be placed on the right side of the line of traction as to counteract the tendency of the harrows to turn from left to right. But further, the position of P is not fixed, but must vary with the roughness of the surface over which the harrows are dragged. Hence, not only must the staple P be placed somewhat to the left hand, but there must be the power of moving it more or less towards the left hand, according to the roughness of the surface passed over. This is effected by the iron plates, with holes, of which mention has been made, and by means of which the driver can readily shift the line of draught more or less to the left hand, as may be required.

A species of harrow was formerly much in use, and is still sometimes employed, of much greater weight and dimensions than the ordinary kinds, each single harrow being drawn by two horses.

Fig. 22.



These large harrows were termed Breaks. They were intended to

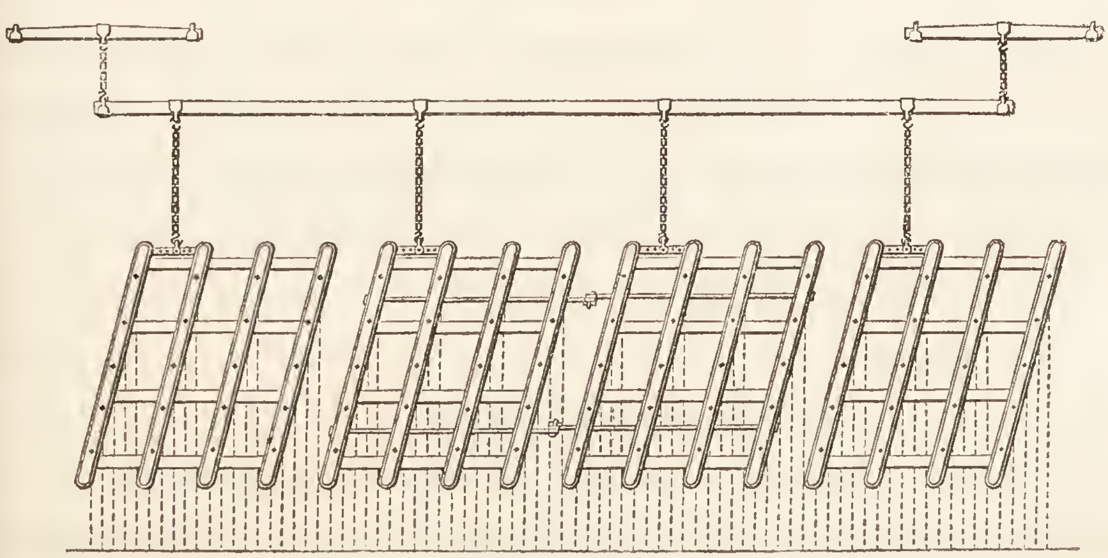
till the stronger clays, at a time when they were too hard to be impressed by the teeth of the common harrow. There were differences in the form of these instruments. One method of their construction is represented in Fig. 22, in which there are five large bars, and twenty-five teeth, and where the line of draught is so attached as that the teeth shall impress the ground at equal distances.

The heavy harrows of this kind, however cannot be said to be indispensable, even on the most stubborn clays, since, at those times when the lighter harrows are unable to operate, other instruments may be employed.

Sometimes a light kind of harrow, with a greater number of teeth, is used for covering the smaller seeds, as those of the clovers and grasses. These light harrows do this species of work better than the common kinds, and hence many farmers have one or more pairs of them for the specific purpose of covering the smaller seeds.

To prevent injury to the surface, when it is necessary to sow land in a very wet state, several harrows may be attached together, and the horses made to walk in the open furrows of the ridges, to be afterwards described. These harrows may be attached to an axle, mounted on wheels, stretching the breadth of the ridge. But the same purpose may be more simply effected by merely attaching the harrows to a beam of wood of a length sufficient to stretch across the ridge, in which case the two middle harrows

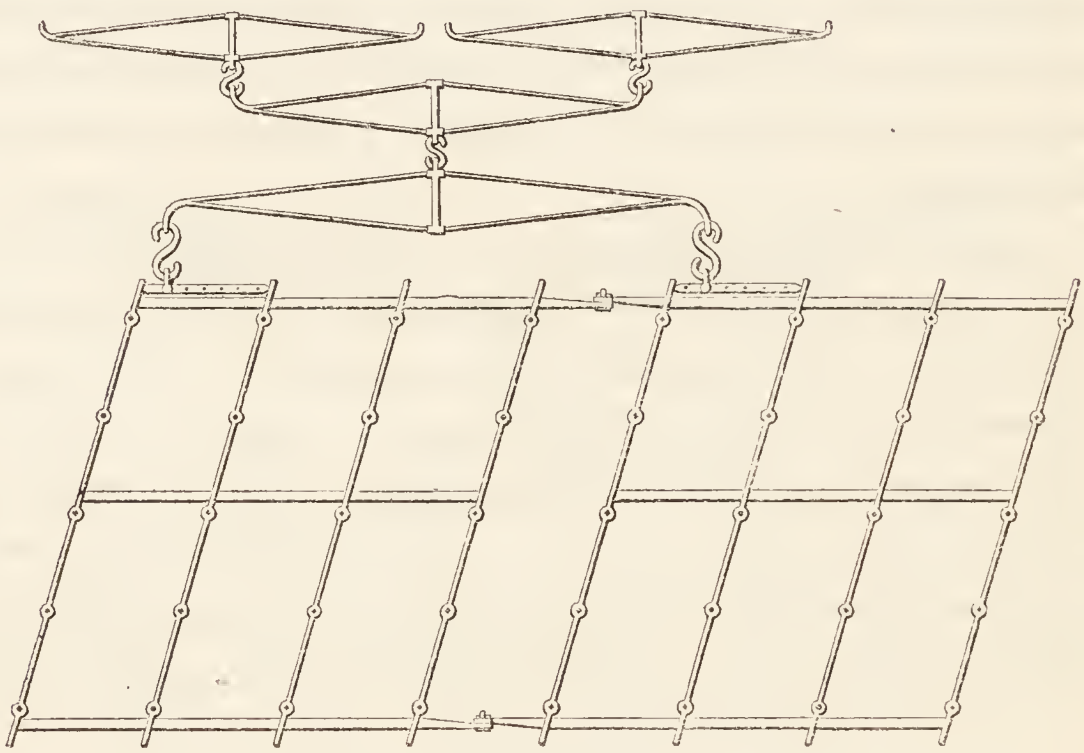
Fig. 23.



may be connected together by hinges, in the usual manner, while, to keep the outer ones at the distance required, each of them may be attached to the cross beam, in the manner shewn in Fig. 23.

The harrow has been here described as formed of wood, with teeth of iron. The whole, however, may be formed of malleable iron. The advantages of the iron harrow are, that it is more durable, and that a smaller surface being exposed to the resistance of obstacles on the ground, it is not so much resisted as when the frame is of wood. On this account it does somewhat more work in proportion to its weight. The following figure represents the harrow as formed of iron.

Fig. 24.



In these figures, the harrows are shewn as closely connected by their hinges; but they may be also more loosely connected, so that each harrow shall have a little separate play, and this is conceived to be an improvement in the construction.

(3.) *THE GRUBBER.*

The uses of the harrow, it has been seen, are to pulverize the

ground which has been subjected to the action of the plough, to disengage from it the roots of plants and other substances which it may contain, and to cover the seeds which are sown upon the surface.

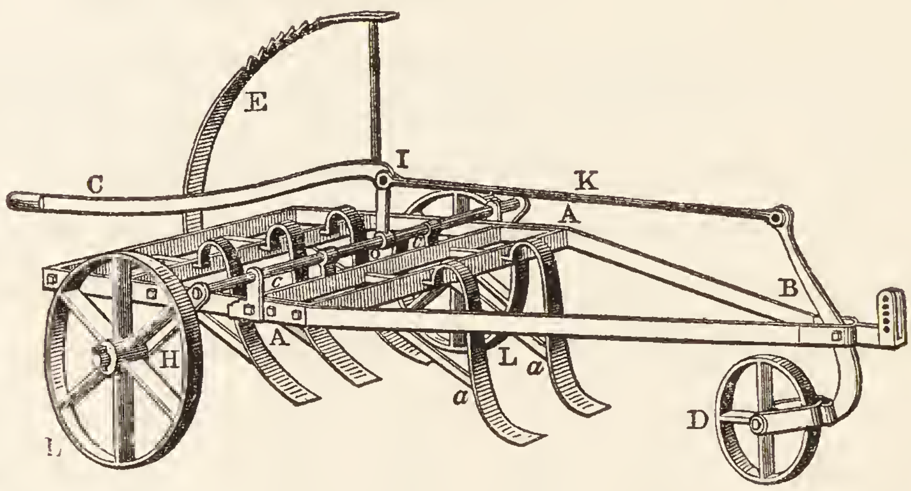
The harrow, however, performs imperfectly a part of these operations. It is not well suited to penetrate the ground, and drag up the roots of plants beneath the surface. The teeth being forced down solely by their own weight and that of the frame in which they are fixed, which is not considerable, they are ill fitted to make an impression upon the ground, and they are easily thrown out of it by the obstacles which they encounter. In soil which is in any degree tenacious, therefore, the impression made by the teeth of the harrow is often very slight. Were the teeth, as was before observed, formed like the coulter of a plough, and set in the same position, they would better insinuate themselves into the ground, and be somewhat less liable to be forced out of it. But the harrow, from its nature, could only admit of this construction in a very limited degree; for were the teeth to form a sharp angle with the framework in which they were set, the roots and other substances disengaged from the ground would be collected at the angles, and would thus be carried along with the harrow and impede its progress; while the difficulty would be increased of freeing the teeth from the substances collected.

To obviate these defects of the harrow, instruments have been employed, which, from their weight and construction, are better able to penetrate the soil, and maintain their position at the depth required. They are termed Grubbers, Cultivators, Extirpators, Scarifiers, &c. They are of greatly more recent introduction into agriculture than the plough and the harrow.

Of this class of instruments, one termed Finlaison's harrow, from the name of its inventor, Mr John Finlaison, has been extensively employed. It is made wholly of malleable iron, and consists of a frame supported by wheels, and having inserted in it a certain number of curved teeth or prongs. It is so formed that the wheels can be raised or depressed, so that the frame can be brought nearer to the surface of the ground, or raised more

above it, by which means the prongs penetrate the soil to a greater or less depth. This instrument was originally formed with nine prongs in two rows, and required a power of four horses to work it. It has now been lessened in weight, and the number of prongs reduced to five, so that it can be readily worked by a pair of horses. It has further undergone certain modifications, so that the frame with its prongs can be more readily raised or depressed, and the prongs more easily set at a greater or less depth, or raised wholly out of the ground, by the workman. The following figure will shew the form of the machine as it is now constructed.

Fig. 25.



It consists of two parallel sides AA, with two sets or pairs of cross-bars, as shewn in the figure. Into the hindmost of these sets are inserted three curved teeth or prongs, and into the foremost set two prongs. From the foremost set of bars, the sides begin to converge, so as to meet at B, where there is a bent lever moveable on a bolt, and connected with the wheel D, which runs upon the surface. This lever is attached by a bolt to the rod K, and this rod again by a bolt at I with the handle C. The handle is bent at the same bolt I, and connected at *o* with the horizontal rod *c c*, by which means, when the handle is elevated or depressed, the rod *c c* is turned. This rod has an arm at each extremity, H, at right angles to it, which carry at their ends the hind-wheels LL. Standing upon the frame, in the manner shewn in the figure, is a curved bar E, with a set of notches at one side, so that the handle, being raised or depressed, can be fixed at any given posi-

tion. When the handle is depressed, the radial part *o* is drawn back, and, consequently, the rod K; and thus the wheel D is pressed downward, the point of the frame B rising in the same degree. Again, by the same depression of the handle, the rod *c* is turned, and the arms HH are placed more vertical, and the wheels LL are lowered; or, in other words, the frame is raised. Thus the depression of the handle raises the whole of the frame with its prongs. Again, when the handle is elevated, the operation is reversed; the wheels are raised, and, consequently, the frame approaches nearer to the ground, and the prongs penetrate deeper. Thus the prongs can be elevated or depressed at pleasure; and thus by fixing the handle in the notches at a greater or less height, the prongs work at a greater or less depth in the soil. By pressing the handle sufficiently down, the prongs can be raised entirely out of the ground, which is required when turning at the end of ridges, or taking the machine from one place to another.

The curvature given to the prongs is for the purpose of preventing any roots or other substances raised from the soil from collecting and impeding the machine. They are supported by stays *a a*, and they cover a space of about 4 feet 4 inches.

Other varieties of this class of instruments are adopted. One constructed by Mr Kirkwood of Tranent, was described in the former editions of this work, and recently, an elegant form of the machine has been proposed by Earl Ducie. It is not, however, necessary to describe the various modifications of this class of instruments: that which has been represented is well adapted to its ends, is simple in form, and calculated to endure the ordinary kinds of work in which it has to be employed.

The introduction of this class of instruments into tillage must be regarded as beneficial and important. When land is full of root-weeds, the repeated operation of the plough, the harrow, and the roller, is resorted to for tilling and cleaning it. In these cases the grubber is a useful assistant, and may frequently supersede the necessity of one or more ploughings.

The grubber can be made to go to any depth which may be required, and thus the soil can either be stirred to the depth at which

it had been originally ploughed, or to such lesser depth as may be deemed expedient. It is, in this respect, greatly superior to the harrow, which we cannot regulate in this manner. The employment of the grubber, however, does not supersede that of the harrow in the pulverization of the ground and disengaging of the roots of weeds. The harrow is still to be used in conjunction with the grubber, and especially for collecting into heaps the roots of the plants brought to the surface.

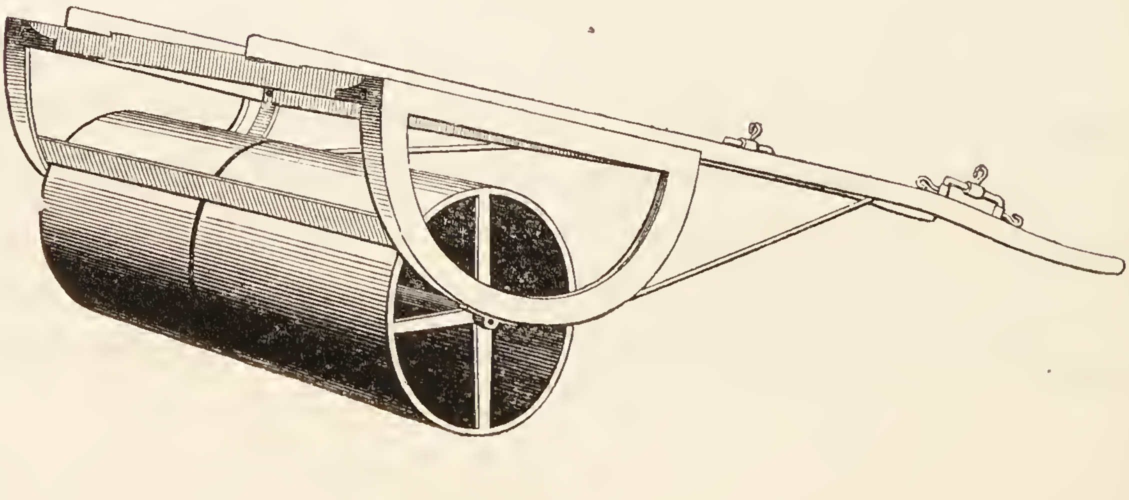
In the same class of instruments is one employed in some parts of England, termed a drag. The drag is merely a strong triangular harrow, kept in the ground by handles, assisted a little by the form of the teeth. It is usually drawn by four horses yoked abreast, and can go over from eight to ten acres in the day. The land being ploughed, the drag passes across the field, and then the harrows follow to complete the operation and collect the weeds.

(4.) *THE ROLLER.*

The Roller is an instrument intended either to smooth and consolidate the surface of the ground, or to pulverize the clods of earth turned up by the action of the plough and the harrow.

The roller chiefly employed is a solid cylinder of wood, or a hollow cylinder of cast-iron, surmounted by a strong framework of wood, in the shafts of which is yoked one of the animals of draught. The other animal, when two are employed, is attached by chains to the shafts, and moves in a line before. The manner in which the frame surmounts the cylinder, on the pivots of which it rests, will appear in the following figure.

Fig. 26.



The length of the cylinder of the roller may be 5 feet, and its diameter 24 inches. The substitution of cast-iron for wood is a great improvement in the construction of this machine, because the iron surface is less apt than the wood to collect mud as it moves along.

Frequently, instead of one long roller, the cylinder is divided into two, as shewn in the figure, so that each part may revolve separately. The design of this is to diminish the labour of the cattle in turning. Sometimes upon the frame is fixed a large box, in which are put stones to increase the weight. The weight of the roller, however, will be best increased by adding to that of the cylinder; for the adding to the weight of the frame increases the friction in the way in which it is most considerable in the machine, namely, by the pressure of the surmounting frame upon the pivots. For the same reason, it is an error to render the frame too heavy, the weight being always better increased by an addition to the weight of the cylinder, than to that of the frame.

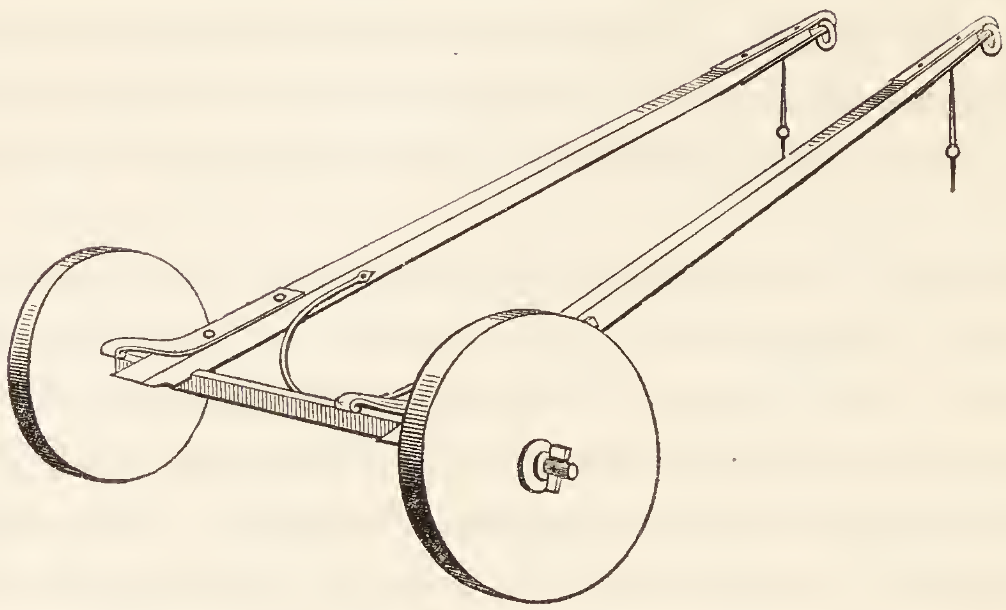
In the construction of rollers, the cylinder is now made of larger diameter than by the older practice: and it is conceived that it can be fairly deduced from a consideration of the form and mode of action of the machine, that, comparing together two rollers with cylinders of unequal diameter, the one with the larger cylinder will be more efficacious than that with the smaller cylinder, because a greater weight can be brought, by the exertion of the same force, to act upon the ground.

The manner of using the roller, and the cases in which it is to be employed, will be afterwards explained.

The weight of the roller may vary with the nature of the soil upon which it is to act. On farms of stiff clays it may be from 16 to 20 cwt., and on the lighter class of soil a weight of 12 cwt. is sufficient.

The cast-iron roller is subject to be broken when dragged along a hard road, to obviate which may be employed a low frame on wheels, on which the roller is then to be put.

Fig. 27.



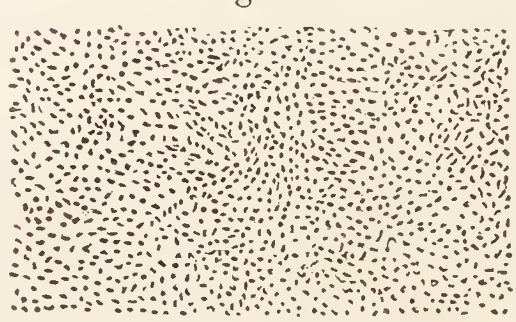
2. Machines for Sowing.

(1.) *MACHINES FOR SOWING CORN IN ROWS.*

The seeds of the different kinds of corn may be sown, either by being scattered irregularly upon the surface, or by being deposited in rows at given distances from one another. The first method may be practised by the hand, the seeds being scattered from a basket, or from a sheet slung over the shoulder of the workman.

When seeds are scattered upon the surface, which is termed sowing broadcast, they fall upon it irregularly. They cannot be placed at equal distances from one another, but nevertheless, if the operation be performed well, the inequality of distance between individual seeds is too inconsiderable to affect the general result, and the average distance is sufficiently preserved, thus:

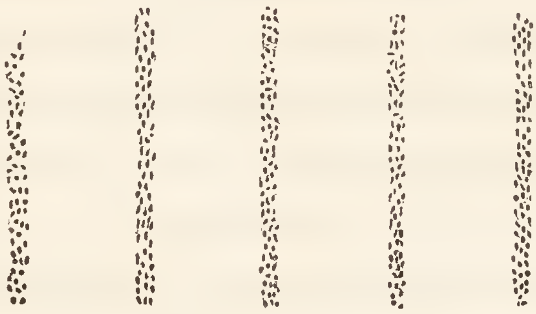
Fig. 28.



For the purpose, however, of allowing the ground to be tilled, and

weeds to be destroyed during the growth of the plants, the seeds are frequently sown in rows, at given distances from one another, as 9, 10, or 12 inches.

Fig. 29.



In this case there is an interval between the rows of seeds, which, until the plants shall have spread their leaves and stems over it, may be tilled by hoes or other means. The sowing of seeds in this manner is termed the row or drill system; and different kinds of instruments are employed for sowing, according as the seeds may be those of the cereal grasses, as wheat; of certain leguminous plants, as the bean; or of smaller seeds, as the turnip.

Various modes of construction have been adopted for this class of machines. Generally a framework is placed upon two wheels, and upon this is an oblong box for containing the seeds. From the axle of the wheels motion is communicated to a spindle or axle, which passes horizontally through the lower part of the box, and upon this axle may be fixed, at the distances required, a series of grooved or fluted cylinders.

Fig. 30.

There are apertures formed near the bottom of the box, and as each cylinder revolves amongst the seeds, a certain portion of them is collected in the grooves at each revolution, and is carried round in the grooves, and falls through these apertures. By making the grooves larger or smaller, so as to contain a larger or smaller quantity of seeds, or by making the apertures of the seed-box larger or smaller, so as to allow a larger or smaller quantity of seeds to

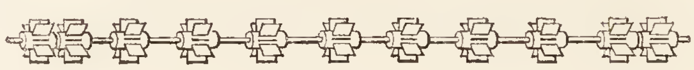
pass through, the machine can be made to sow the seeds more or less thick, as may be required.

The seeds, after passing through the apertures, fall into tubes or funnels, through which they are conveyed to the ground. Immediately before the lower part of each funnel is a sharp hollow coulter of iron, which encloses the lower part of the tube, and makes a rut in the ground into which the seeds fall. By these means they are sown in the quantity required, and at the depth to which we choose to set the coulters.

To allow the rows to be at larger or smaller intervals, the cylinders are generally moveable upon the spindle, so as that they may be set at any equal distances, as 9, 10, 12, or more inches. The coulters are made to move at the depth required, and to be lifted up along with the tubes or funnels when necessary, as at the turning at the ends of ridges, and the encountering of obstacles of any kind.

Sometimes the axle, instead of having cylinders upon it with grooves, has a series of small pinions or teeth.

Fig. 31.



Or, in place of the teeth, there is employed a series of stiff brushes. The teeth or brushes revolve in the same manner as the fluted cylinders, and, by keeping the seeds in motion, cause them to fall through the little apertures or holes near the bottom of the box. The holes are made to be enlarged or diminished by means of a sliding iron-plate, placed upon them, with an equal number of similar holes. When the holes of the seed-box and the iron-plate correspond, that is, when they are placed exactly one upon the other, the holes through which the seeds drop are of their largest size. But by moving the iron-plate a little to a side, the holes do not entirely correspond, and hence the holes through which the seeds fall are lessened; and by moving the iron-plate still further to one side, so as that no part of the two sets of holes shall correspond, those of the seed-box are entirely covered. The iron-

plate which thus lessens or closes the apertures of the seed-box, is moved by a lever, and fixed in its position by screws.

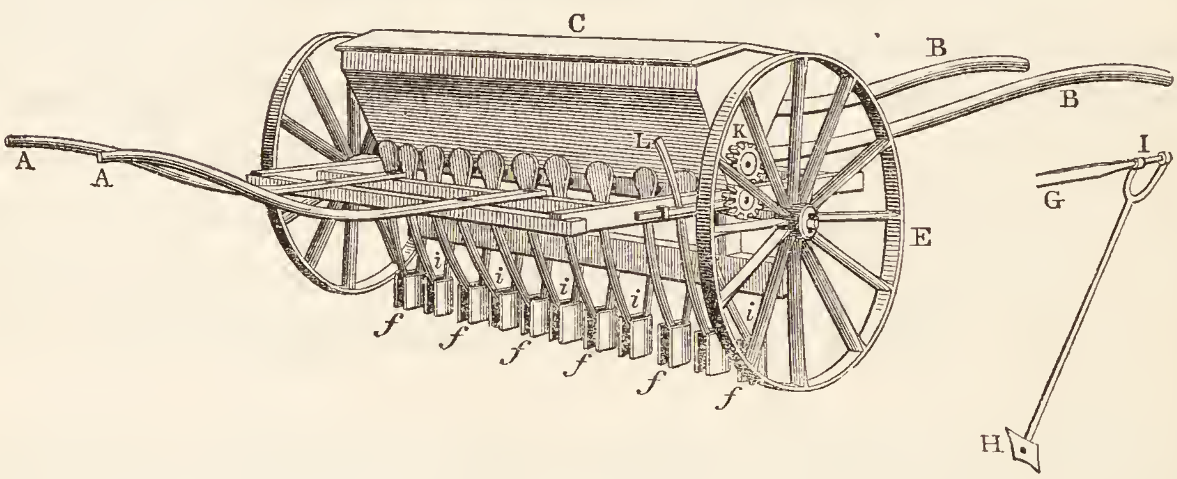
In Fig. 32, the principle of construction is that of teeth or brushes fixed upon an axle, which is more simple than when the method of grooved cylinders is adopted, and is found in practice to be equally or more efficient.

C represents the seed-box, formed with a lid at top, by which the seeds are introduced. At its lower part are the holes through which the seeds fall, and covering them all is a thin iron-plate with corresponding apertures. By moving the iron-plate, which is done by means of a lever, the holes of the seed-box are enlarged or diminished to the degree required, and *i i i i*, &c., are a series of tin tubes, enlarged at the upper part, where they are in contact with the seed-box, which lead to the hollow iron coulters *f f f f*, &c. These hollow coulters are sharp before and open behind. They inclose the tin tubes at their lower end, and make a rut in the ground into which the seeds fall. In the figure, 11 of these coulters, with their corresponding tubes are shewn; and they are so made as that, by means of a simple contrivance, some of them may be closed up, and the others placed at equal distances from one another. In this way 7, 9, or 11 rows may be sown as may be required.

At the bottom of the seed-box within, is placed the horizontal spindle, on which are fixed the teeth or brushes, which, agitating the seeds in the box, cause them to fall through the holes into the tubes. Motion is given to this spindle by means of a toothed wheel upon the axle of the wheel E. This moves a small intermediate wheel, and this again the wheel K, placed upon the end of the spindle. In this manner the spindle, with its brushes or wheels, revolves amongst the seeds, and, by the motion which it gives to them, causes them to fall through the holes into the tubes, whence they are conveyed to the ground. When the spindle is stopped, scarcely any seeds fall through the apertures, and by means of a lever L, the workman has the power of throwing the moving wheel out of geer, and thus stopping at once the revolution of the spindle. BB are the shafts, attached by means of hinges to the machine, between which the

animal of draught walks; and AA are the handles upon which the workman presses, and by elevating which, he is enabled to lift up the seed-box and coulters, so that the latter may, if required, be raised entirely out of the ground. G represents a part of a long wooden bar, with a rod and sharp piece of iron H, fixed to it by hinges at I. The use of this is, that when the machine moves across ridges, which is the way in which it is often employed, a mark or rut may be made in the ground; and when it returns, the animal of draught walks in the rut or track which has thus been formed, and which is, accordingly, the guide or mark by which the workman is enabled to direct the course of the machine. This marker is made to be lifted to either side, as may be required. It is not an indispensable appendage.

Fig. 32.



(2.) *MACHINES FOR SOWING CORN AND GRASS SEEDS BROADCAST.*

The sowing of corn from the hand is attended with some uncertainty, being dependent, for the accuracy of the execution, upon the skill and attention of the sower. The regularity of the work is also affected by winds. In either case, the means rarely exist of detecting the degree of imperfection, until the plants are above ground, when it is too late to correct it. As a remedy for these inconveniences, a machine has been introduced into agriculture, for sowing the seeds of corn and grasses broadcast. The great recommendation of this machine is, the regularity and certainty with which it performs the work, the saving of seeds, and the ren-

dering the execution independent of unskilfulness and the want of care in the operator.

The machine consists of an oblong box, 16 feet or more in length, supported upon a framework with three wheels. Working at the bottom of the inside of this box, is a horizontal spindle AB, Fig. 33, upon which is fixed a series of pinions (or a spindle OP, on which is fixed a series of hard brushes), at the distance from one another of about 7 inches. Motion is given to this spindle from one of the hinder wheels, by means of the axle C, upon the end of which is fixed the mitred wheel D. This works into a small mitred wheel upon the little shaft E; which again, by means of another mitred wheel working into a similar wheel F, gives motion to the horizontal spindle. In this manner the spindle with its pinions or brushes, is made to revolve as the machine moves forward. At the lower part of the seed-box within, are hollowed out cavities, in which the several pinions work; and at the bottom of each of these cavities is a small aperture or hole, through which the seeds fall. There is thus along the whole bottom of the seed-box, a line of holes; and a long thin iron-plate upon the outside of the seed-box is made with similar holes. This iron-plate is moveable by means of levers, and is made to be fixed in a given position by screws. When the holes of the iron-plate are placed so as to correspond exactly with those of the seed-box, the holes through which the seeds fall are of their largest size. By pressing the iron-plate a little to one side, it partially covers the holes of the seed-box, and thus the holes through which the seeds fall are diminished; by pressing the iron-plate still more to a side, the holes of the seed-box are covered, and no more seeds fall through. In this manner, precisely as in the case of the drill-sowing machine, the apertures of the seed-box can be enlarged or diminished, so as to allow a larger or a smaller quantity of seeds to fall through. The seeds, however, in place of falling into tubes, and being thus conveyed to the ground, and deposited in rows, fall at once upon the ground, and so are sown broadcast. They are then covered by the harrow, in the manner to be afterwards described.

Fig. 33.

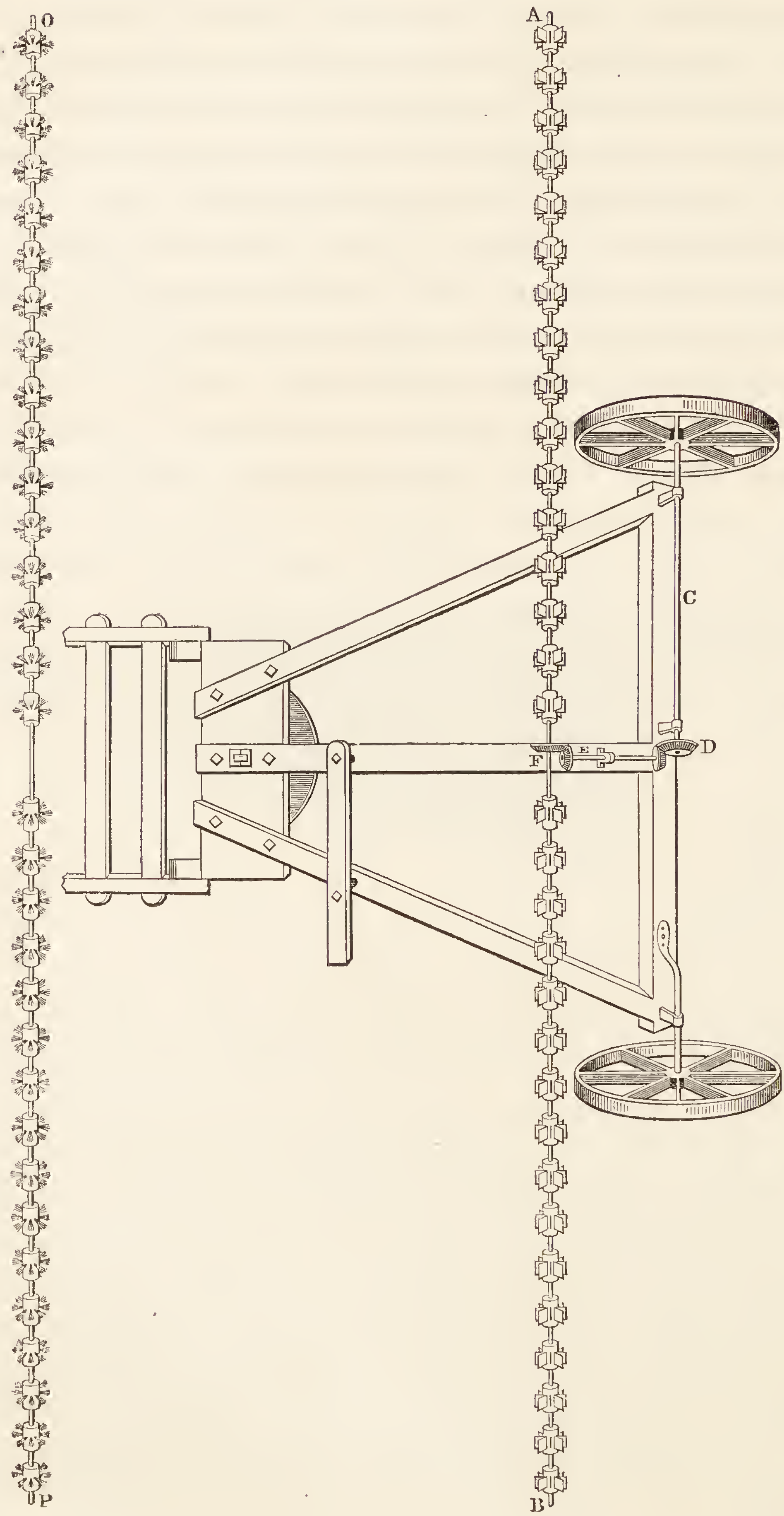
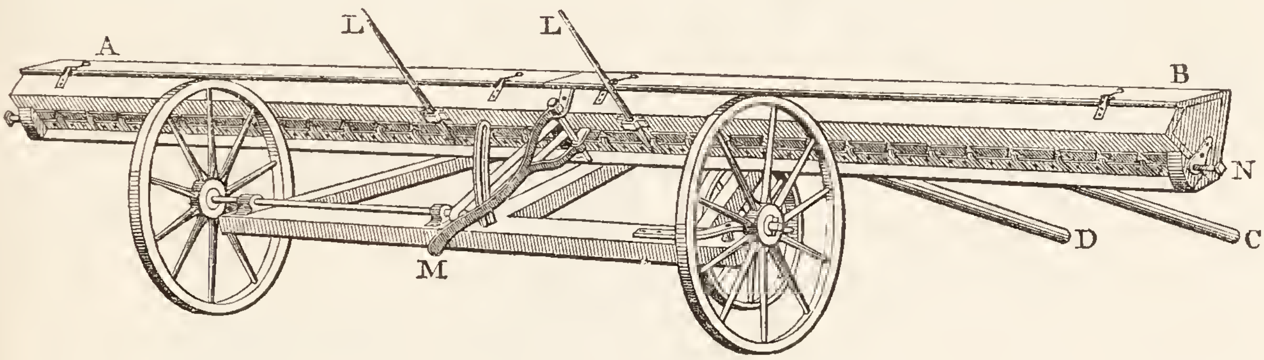


Fig. 34 is a perspective view of the machine. AB represents the long wooden seed-box. CD are the shafts for the attachment of the animal of draught. LL are two small levers for the purpose of moving the iron-plate, and N is one of the screws for fixing it in its position. M is a lever acting vertically for the purpose of changing the position of the seed-box, which is sometimes required in the case of a steep ascent.

Fig. 34.



The animal of draught between the shafts walks in the hollow of the ridge, in which also moves the fore-wheel, which, however, is scarcely seen in the figure, being hidden by the seed-box and frame. The long wooden box extends over half the space of each adjoining ridge, and thus the breadth of an entire ridge is sown at once. In order that the machine may be adapted to variations in the breadth of ridges, some of the holes at each end are made to be closed by means of sliders. The workman walks behind. A man and a horse with this machine, with the assistant required to bring forward the seeds and empty them into the seed-box, will sow from 20 to 25 acres in a day.

The regular manner in which the seeds are sown by means of this kind of machine, renders less seeds necessary than when the common method of sowing by the hand is practised. And, further, this greater regularity in the distance of the seeds from one another, produces a more equal growth or braird of the plants.

Besides the sowing of the cereal grains, the machine is well adapted to the sowing of the seeds of the grasses and clovers. The seeds of these plants are very minute, and more difficulty exists in sowing them with regularity than the larger grains, and

in an especial manner during winds, when, from the lightness of the seeds, they are easily blown away. When the seeds of clovers and grasses are to be sown, the spindle with brushes, in place of that with pinions, is to be employed.

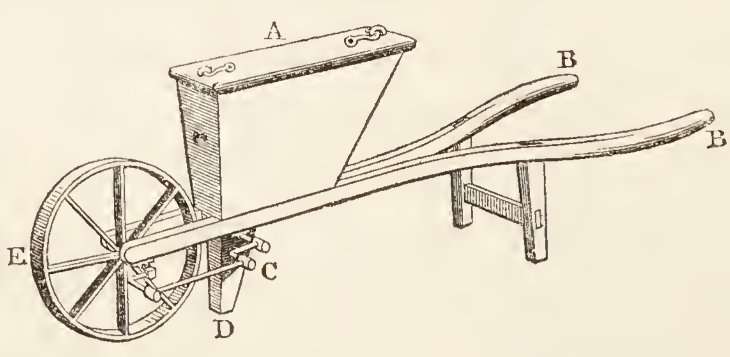
(3.) *MACHINES FOR SOWING THE SEEDS OF THE BEAN AND PEA.*

The seeds of the bean being of larger size than those of the cereal grasses, a peculiar kind of machine is employed for sowing them.

The simplest of these machines consists of a seed-box, in the bottom of which works a grooved cylinder. At each revolution of the cylinder a quantity of seeds, dependent upon the size of the grooves, is carried round, and these falling into a tube at the bottom are conveyed to the ground. This machine is generally made to sow only one row at a time. It is thus so light as to be pushed forward by the hand, and is moved upon a single wheel like a wheelbarrow. From this wheel, motion is conveyed to the cylinder by means of cranks.

In the following figure, A is the seed-box, at the bottom of which the grooved cylinder works; BB are the handles held elevated by the workmen; E is the wheel on which the machine moves; C is one of the cranks connected with this wheel, which give motion to the grooved cylinder within the box; D is the tube through which the seeds fall into the rut prepared for them in the ground, in the manner to be described when treating of the culture of the bean.

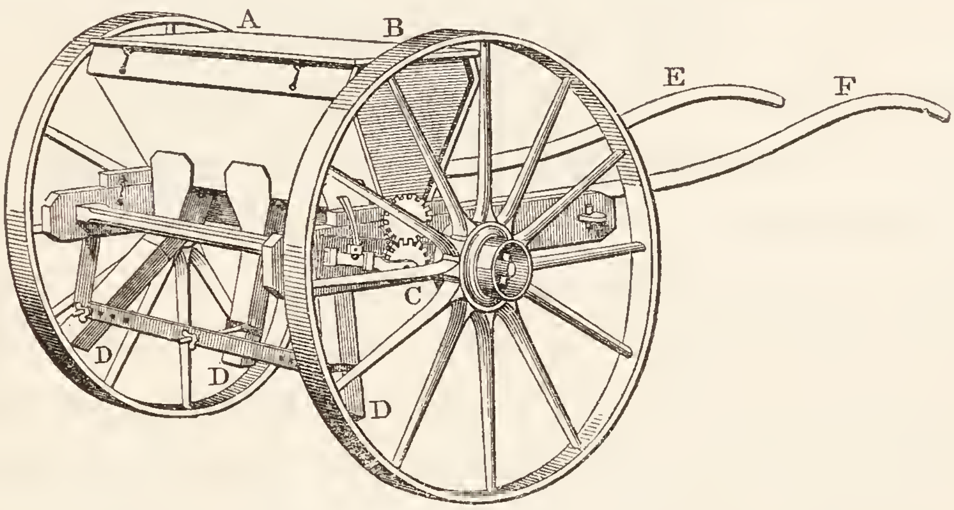
Fig. 35.



But a better machine is now employed for sowing the seeds of

the bean as well as of the pea. In this implement, as in the other, a grooved cylinder works in the bottom of a seed-box; but the seeds are conveyed to the ground by three tubes in place of one, so that three rows are sown at once. The machine is drawn by a single horse, and the seeds are deposited in the hollows between drills previously formed, in the manner to be explained when describing the culture of the bean and pea. Fig. 36 represents this machine: AB is the seed-box, and C one of the wheels by which motion is conveyed to the grooved cylinder; DDD are the tubes

Fig. 36.



through which the seeds fall, and FF the shafts to which the animal of draught is attached.

(4.) *MACHINES FOR SOWING THE SMALLER SEEDS IN ROWS.*

The seeds of the turnip, and a few other plants cultivated in rows, require a peculiar class of machines.

These differ very much in the details of their construction, and are more or less perfect in different parts of the country. Sometimes the method before explained of grooved cylinders is adopted, the size and mode of action of these being suited to the minute seeds to be sown. The seeds are then carried to the ground in tubes, defended at their lower part by coulters, which make ruts in the ground into which the seeds fall.

In place, however, of using grooved cylinders, the more common method is to place the seeds in cylindrical boxes of iron or

tin, which are made to revolve, and which being perforated in a line all round, the seeds fall through as the boxes revolve. Embracing the cylindrical box is a thin iron or tin plate, in which also are perforated sets of holes, by slight change in the position of which a greater or smaller number of holes in the boxes can be covered, and so a greater or smaller quantity of seeds allowed to fall through.

Fig. 37 represents this method of construction. AA are two boxes or hollow cylinders of tin, with a row of holes round each cylinder. Into these cylinders the seeds are introduced by means of apertures with sliding lids. Motion is given to them by a pinion upon the axle of the wheel at B. This acting upon the intermediate pinion C gives motion to the pinion upon the end of the axle D. The cylinders AA being fixed upon this axle, they revolve in proportion as the machine is moved forward. The seeds falling into the tubes GG are conveyed to the ground. The hollow coulters HH defend the lower extremity of the tubes, and make ruts, into which the seeds fall. I is a lever, which, by means of a toothed wheel working into the teeth of the iron-plates KK, can move the lower ends of the coulters and tubes to a greater or smaller distance from each other, according as the rows may be somewhat more or less distant.

Fig. 37.

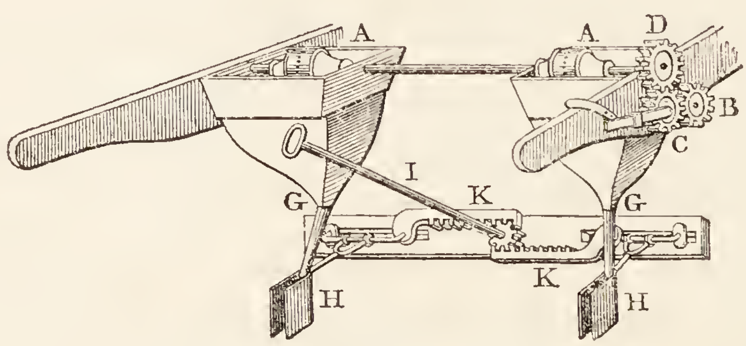
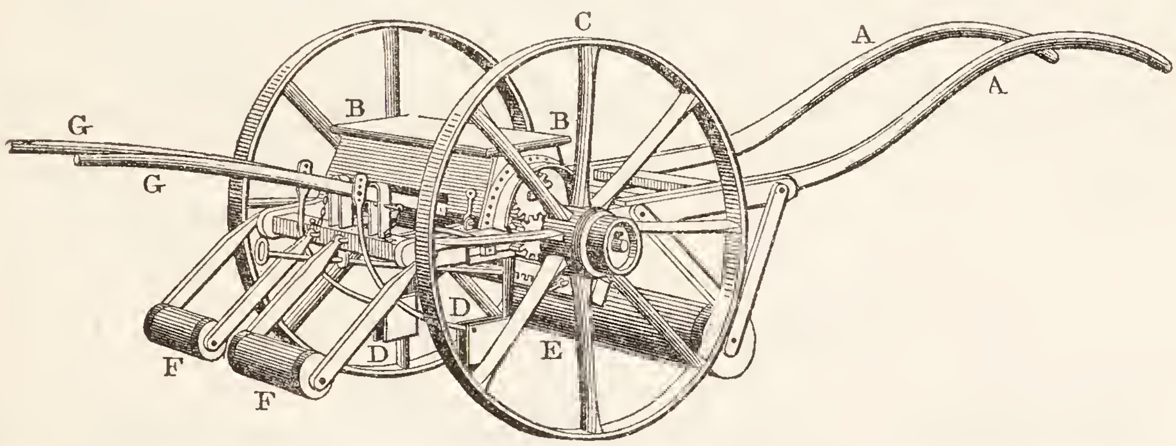


Fig. 38 represents the machine complete. AA are the shafts, to which is yoked the animal of draught. BB is a wooden box, in which are contained the cylinders, to which motion is conveyed by the pinion fixed upon the axle of the large wheel C. DD are the hollow iron coulters, in which the tubes for conducting the seeds to the ground terminate. FF are two light wooden rollers,

which follow each track of the coulters, and cover the seed; but which are sometimes omitted. E is a wooden roller in front, the use of which will be understood on describing the turnip-culture in the sequel. It is sufficient here to state, that the seeds of the turnip are sown on the tops of little raised drills, and that the effect of this roller is to flatten and compress these drills just

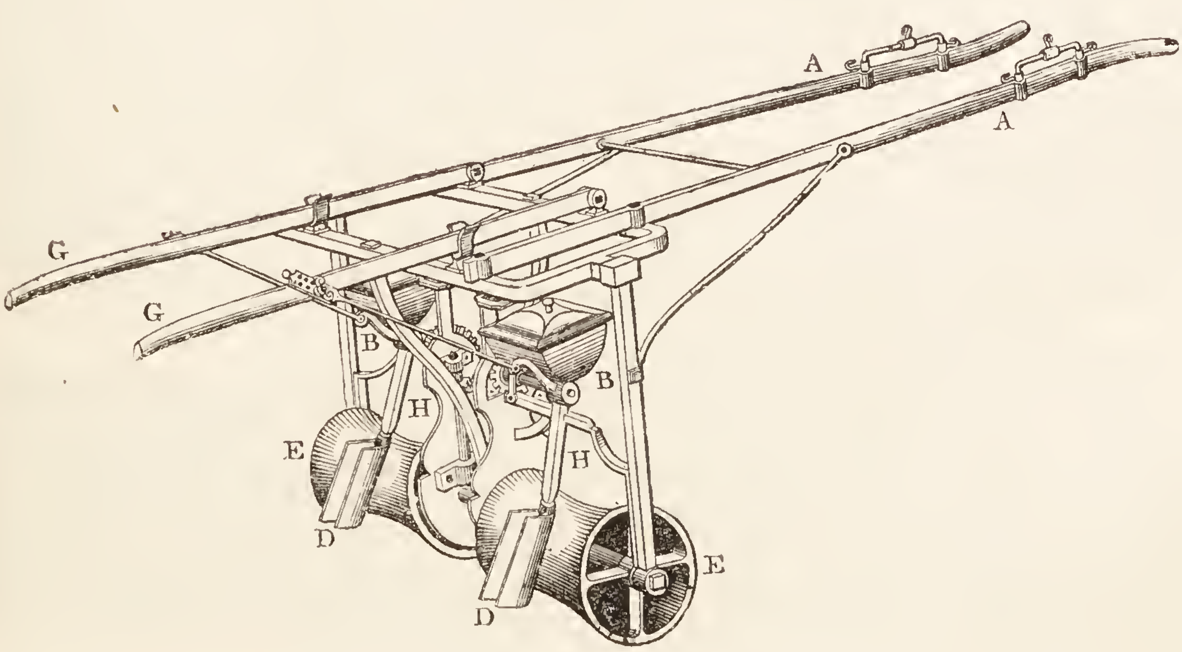
Fig. 38.



before the seeds are sown. GG are two handles which are held by the workman. These are attached to the coulters in such a manner, that when either handle is lifted up, the corresponding coulter also is raised; and thus the workman has the power of lifting up either coulter, when impeded by roots or other obstacles.

The following figure represents a machine of this class as formed wholly of iron, and with a variation in the mode of its construction. BB represent the boxes in which the seeds are contained.

Fig. 39.



EE are two rollers hollowed out so as to suit the curvature of the drills, and from the axle of which motion is conveyed to the grooved cylinders contained in the boxes. HH are the tubes which convey the seeds from the boxes to the hollow coulters DD. AA are the shafts to which the animal of draught is yoked, and GG the handles held by the workman.

Sometimes the machines of this class are made to sow only one row at a time; but it is an improvement that they be made to sow two rows at once, both on account of the saving of labour, and of the greater steadiness with which the larger machine moves forward.

3. Implements for Hoeing.

The machines of this class are those which are employed for the purpose of tilling the intervals of plants which are sown in rows.

The plants which are cultivated in this manner are, in certain cases, the cereal grasses; in other cases, the bean, the pea, and such leguminous plants as are cultivated for their seeds; but, above all, the turnip and other plants of the cabbage family, and the potato, the carrot, the beet, and various plants cultivated chiefly for their roots or tubers.

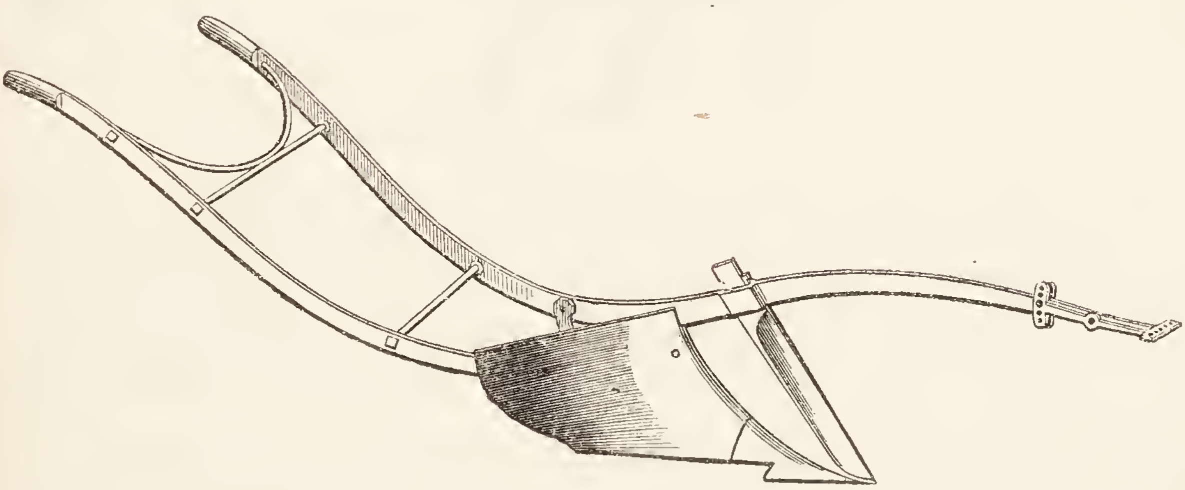
The instrument most generally employed for tilling the intervals of the cereal grasses is a hoe used by the hand; although, where the system is practised to a great extent, it is found convenient to employ a series of hoes, moved by horse-labour. These are commonly flat triangular shares, of such a size as to occupy the interval of the rows, and so formed as to be set at a greater or less distance from one another as may be required; and they are attached to a frame fixed on wheels.

But, in the practice of the farm, the hoeing instruments that may be considered as really essential, are those used for tilling the intervals of leguminous plants, as the pea and bean, of the plants of the cabbage family, and of the various species of plants cultivated for their roots and tubers.

A hoeing instrument for the latter classes of plants is a common plough, formed upon the principle of the plough already described, but of smaller size, and drawn by one horse.

In using this plough, the animal of draught walks in the interval between the rows of plants. The plane of the left-hand side of the plough is made to go as near the line of plants as can be done without injury; and in this manner the plough cuts off a shal-

Fig. 40.



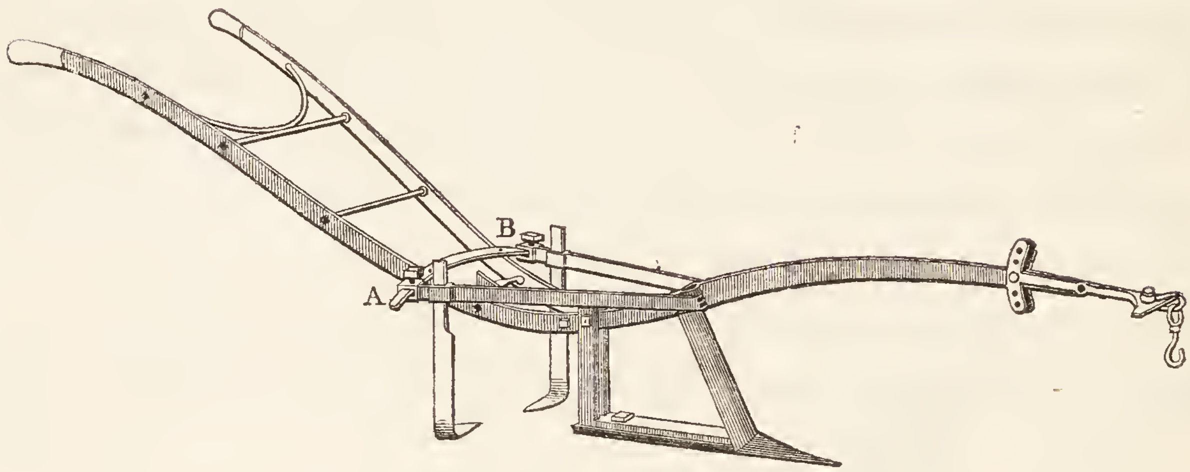
low slice of earth, and lays it in the interval between the rows. The same operation is then performed with the adjoining row of plants, by the plough returning in the same interval; by which means another thin slice is cut off, and thus two furrow-slices are taken from each pair of adjoining rows of plants, and thrown into the middle of the space between them. In place of a single small plough, there has been sometimes employed an instrument with two mould-boards with shares, facing one another, resembling two ploughs, the one a little in advance of the other, but having one beam, and being made sufficiently light to be drawn by one horse.

This is a very efficacious species of tillage, and is frequently used in the case of the first hoeing to be given to potatoes and turnips, in the manner to be afterwards described, and in the case of beans where the land is stiff and the intervals wide.

Besides these instruments, are employed hoes of various construction, which, by means of shares and coulters, or of coulters alone, till at one turn the entire interval between the rows of plants. These are sometimes made with beams in the manner of the plough, and sometimes without beams in the manner of the harrow. Fig.

41 represents an instrument of this class, suited to the different purposes to which it is applied.

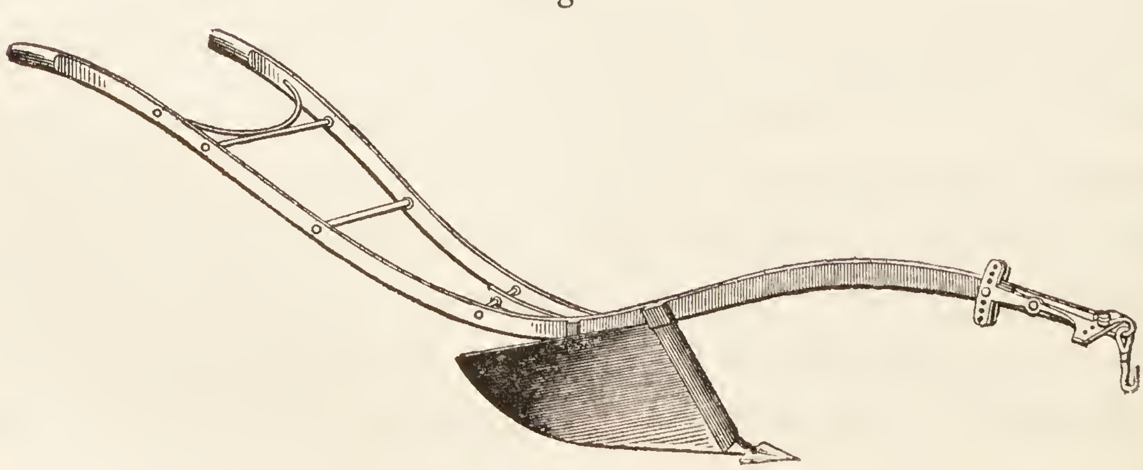
Fig. 41.



It is formed with a beam and handles, like a plough. It has a triangular two-winged share, which passes between the rows of plants. Fixed to the horizontal bars are two upright coulters, bent inwards at the lower extremity. The bars to which these coulters are attached slide upon the cross-bar AB, and are fixed by hinges to the beam, and thus the upright coulters can be placed at such a distance from one another, as to work as near the rows as they can go without cutting or injuring the plants. In this manner, by means of the broad share in the centre, and the coulters at the sides, the entire space between the rows of plants is tilled.

Further, by removing the two lateral coulters, and substituting two mould-boards, a hoeing machine of this kind may be converted into another implement employed in tilling the ground—a double mould-board plough. The effect of using the lateral coulters in tilling, is to move, in part, the earth away from the plants. By substituting the double mould-board plough the operation is re-

Fig. 42.



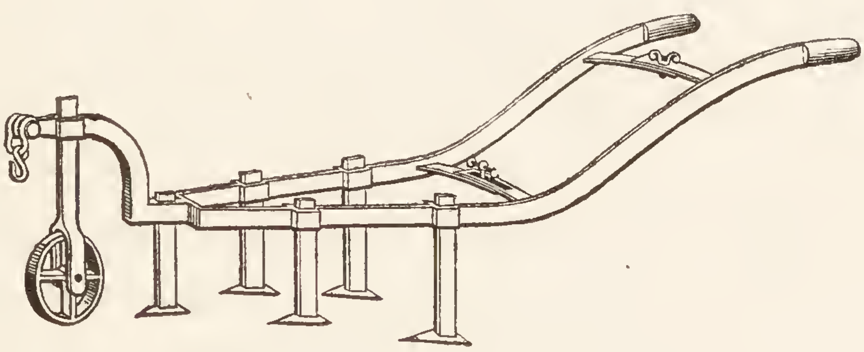
versed; for, by passing along the intervals of the rows, it lays back the earth towards the plants from which it had been moved by the action of the lateral coulters.

Fig. 41 represents the instrument, with its broad share and lateral coulters. Fig. 42 represents it when the coulters and bars to which they are attached are removed, and the two mould-boards are substituted.

Although the machine described will, in most cases, answer the purposes required, yet, in the case of particular classes of soils, or rather in particular conditions of the soil, the broad share is found to raise up the ground in clods or masses, and to be sometimes inconvenient when the land is very full of weeds. In such cases, an instrument with coulters alone may be employed.

The following figure represents one of the simplest that is used, and as efficient as any other. It is best constructed of iron. The coulters are fixed in lateral beams and these beams are formed to be moved at a greater or less distance from one another, as shewn in the figure, so that a wider or narrower interval can be tilled. In front is a little wheel to steady the motion of the instrument.

Fig. 43.



4. Machines for Thrashing and Winnowing.

(1.) *THRASHING-MACHINE.*

The separation of the grain of corn from the straw, has been effected by various means. That which is the most familiar, and which has been derived from the earliest times, is by the flail, a simple instrument, which consists of two staves bound together by tough thongs. One of these staves is held in the hands of the

workman, and with the other the unthrashed corn is beaten with force ; by which means, the grain and husks are separated from the straw, and these again, by the further action of winnowing, from one another.

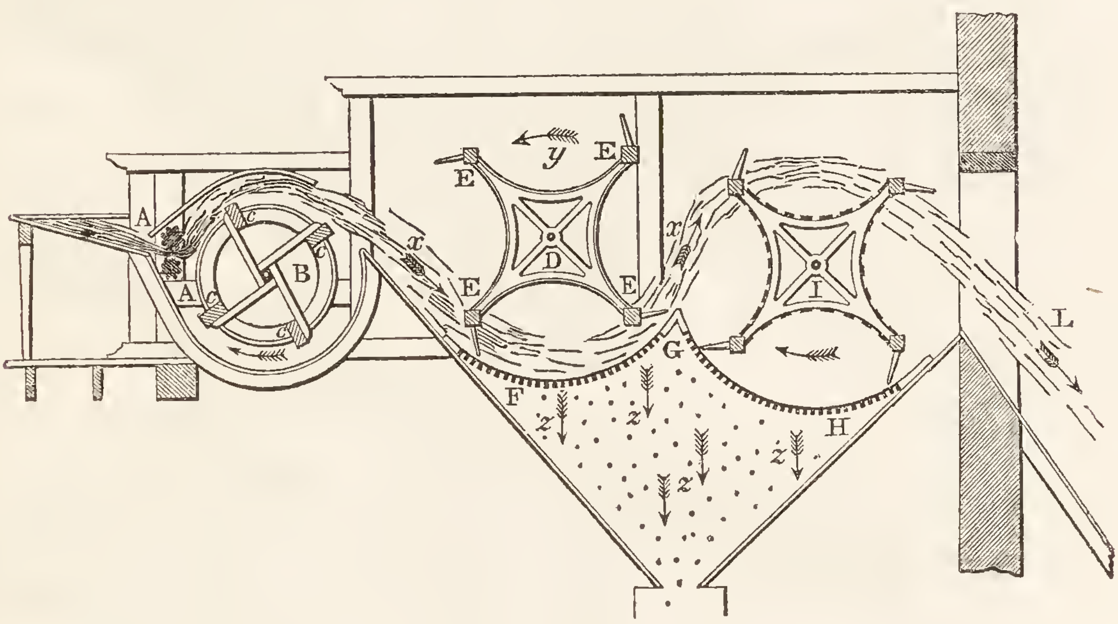
The flail, although efficient in the hands of an expert workman, is but a rude instrument. The operation performed by it is laborious, and the separation of the grains from the stems is often imperfectly executed. As agriculture has advanced, attempts have been naturally made to substitute machinery which might perform the operation required with more facility and greater despatch. These attempts were but partially successful, until the invention of Andrew Meikle, an ingenious mechanic of Scotland, to whom, beyond a question, belongs the honour of having perfected the thrashing-machine. Changes and improvements have indeed been made on certain parts of the original machine; but in all its essential parts, and in the principle of its construction, it remains as it came from the hands of its inventor.

In this machine, the unthrashed corn is made to pass between two revolving rollers. It is held firmly by these, which are of small diameter, and revolve with comparative slowness, while it is acted upon by a set of beaters, as they may be called, placed upon a cylinder, and revolving with great rapidity. The cylinder revolves upon a horizontal axle, while the beaters, consisting of bars covered with iron, are fixed lengthwise upon it, that is, parallel to its axis. The action of these beaters detaches the corn and chaff from the straw, and then, by means of revolving rakes, the straw is shaken, and the corn and chaff are allowed to separate from it. These fall through spars or wire-meshes into another machine, where they undergo the process of winnowing, while the straw itself is carried forward and thrown out of the machine by the action of the revolving rakes.

Fig. 45 represents a transverse section of these parts. In this, AA are two fluted cylinders of iron, working into one another, and between which the unthrashed corn is made to pass. B is the cylinder, upon which are placed the four projections or beaters *cccc*. The cylinder revolving with great rapidity, the beaters act

upon the unthrashed corn, as it is firmly held by the fluted cylinders, and beat and detach the seeds and husks from the stems. The whole passing over the cylinder, is thrown forward in the direction shewn by the arrows *xxx*. It is first acted upon and shaken by the four rakes EEEE, placed upon the hollow cylinder D, moving in the direction of the arrow *y*. It is then thrown forward, and acted upon by an equal number of rakes, placed upon the circumference of the sparred cylinder I, and by them it is thrown out at the end of the machine at L. The bottom of the machine FGH, is so formed with spars, or a species of wire-work, that, while the straw is carried forward by the action of the rakes,

Fig. 44.

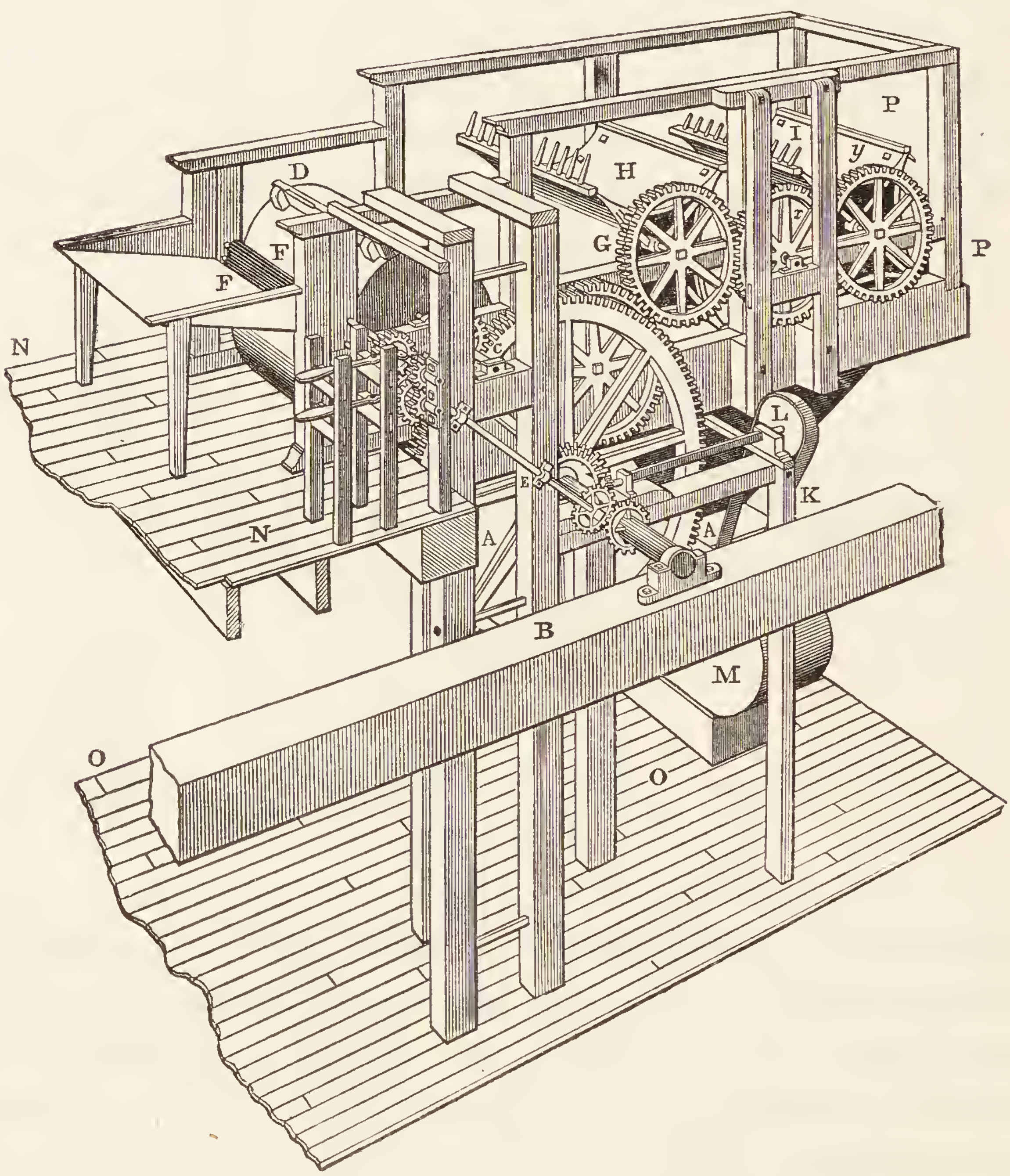


the detached grains of corn and chaff fall down in the direction of the arrows *zzzzz*, into a machine below, in which, by the action of winnowing, the chaff is separated from the grain. The first of the revolving cylinders D, is formed of thin iron, or of wood covered with tin. The second of the cylinders I, is of wood, sparred, so that any corn or chaff not separated by the action of the first rakes, may fall through in passing over the last cylinder; and, by which means, the whole of the detached grain and chaff falls through the sparred or meshed bottom FGH.

The machinery of the thrashing-machine is driven by animal power, or by wind, water, or steam. The parts described are within the apartment or barn in which the thrashing process takes place.

The moving power applied is without the walls of the barn, properly so called. The form of the thrashing parts of the machine is represented in Fig. 45, with the wheels and pinions employed in moving them. Here AA is a large spur-wheel, with its axle resting on the beam B. To this wheel motion is communicated

Fig. 45.



by means of the moving power without the barn, whether that shall be animal power, wind, water, or steam; and this wheel, by means of wheels, pinions, spindles, or belts, gives motion to all the parts of the machine. First, by acting on the pinion C, it gives motion to the revolving cylinder D, on which the beaters are fixed; second, by means of pinions, it gives motion to the inclined

shaft E, and this again, by means of wheels, gives motion to the fluted cylinders FF. Further, by a pinion and intermediate wheel, it gives motion to the spur-wheel G, fixed to the axis of the hollow cylinder H, with its four attached rakes. The spur-wheel G gives motion, through the intermediate wheel x, to the wheel y, fixed on the axle of the cylinder I. Further, by means of the belt K, running on the pulley of the spindle L, motion is communicated to the winnowing-machine M.

In so small a figure it is difficult to represent the details of the construction. It must suffice, therefore, that the reader make himself acquainted with the essential parts of the machine, and the general means by which they are put in motion. The large spur-wheel AA, he will observe, communicates motion to the different parts of the machine, namely, to the fluted rollers FF, between which the unthrashed corn passes, to the revolving cylinder D, with its beaters, to the revolving rakes H and I, and to the belt K, which gives motion to the parts of the winnowing-machine M, which stands below the sparred bottom of the thrashing-machine, and has the corn or chaff conveyed to it through a large hopper. Besides the parts referred to, various devices may be employed for abridging labour, as for carrying away the corn when thrashed, &c.; but these not being essential parts of the machinery, need not be here described.

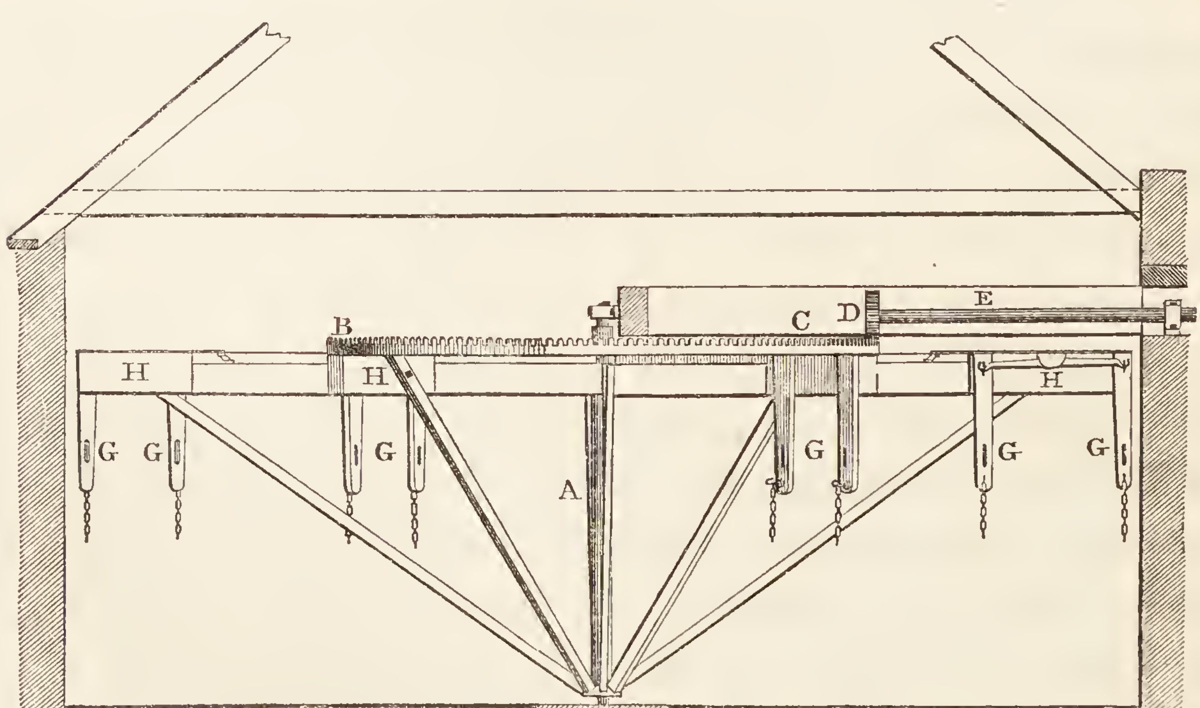
To understand further the general arrangement of the thrashing-machine, it is to be observed, that the barns in which the operations of thrashing, winnowing, &c., are carried on, are in three apartments. NN is the upper storey of the barn, in which the unthrashed corn is placed. OO, immediately underneath this, is an apartment for receiving the corn as it comes from the apertures of the winnowing machine. PP is the part of the barn into which the straw falls, and is called the straw-barn. Into the upper apartment NN, the unthrashed sheaves are carried from the barn-yard, being either thrown into it directly from the carts, or carried up to it by means of an easy gangway on the outside. In the lower apartment OO, which is called the dressing-barn, the corn is received from the winnowing-machine, and made ready for use. In

the large straw-barn PP, the straw is generally piled up until it is required for the purposes of fodder or litter. Between the straw-barn and dressing-barn, a small apartment is partitioned off for receiving and containing the chaff; but deviations are made in the dispositions of these several parts, for the purpose of suiting the buildings of the smaller farms.

A modification of the thrashing-machine has been recently introduced with success. It is, in point of fact, not a thrashing-machine, as it operates by stripping the grain from the straw, and not by beating it. There are no feeding rollers, and the drum or cylinder of the thrashing-machine is furnished with pegs or pins set radially upon its surface, in place of beaters, the arc in which the drum revolves being provided with similar pins. The grain, in passing between them, is effectually stripped from the straw. It matters not, in this machine, whether the grain be broken or laid head to; for, as the straw is pulled out straight by it, the ear is stripped off in any position.

The thrashing-machine, it has been said, is driven by animal power, or by wind, water, or steam. The animal of draught is generally the horse, and from four to six are the numbers usually employed. The animals walk in a circular covered pathway, without the barn. Fig. 46 shews the manner in which they are gene-

Fig. 46.



rally attached, and the means by which motion is conveyed to the large spur-wheel within the barn, already referred to.

A is a vertical shaft. BC is a large wheel with teeth working into the pinion D. This gives motion to the shaft E, and this again to the spur-wheel within the barn, already referred to.

GGGG are vertical posts, descending from long beams HH, placed above the animals of draught. To these posts the animals are yoked by short chains attached to the collar, and, moving in a circular course, they give motion to the apparatus.

The number of horses employed, it has been said, is generally from four to six. The smallest class of machines are those in which only two horses are employed. There is always a waste of labour, however, when less than four horses are used. Whatever be the number employed, the operation of moving the machine is a severe one upon the working cattle, from the dead weight of the draught, and their confined position. For this reason, amongst others, the substitution of mechanical for animal power is always to be preferred where circumstances will admit of its application.

The mechanical power employed may be water or steam. Wind also may be employed, but this is too uncertain and unequal in its operation to be well suited for driving the thrashing-machine.

When water is the power employed, the common machinery of the water-wheel is used. Of the different powers, water, where it can be commanded in sufficient quantity, is the most economical.

But where water cannot be obtained, then the best resource is steam, which, from the great and steady power capable of being applied, admits of an admirable construction of the thrashing-machine. The steam-engine may either be a non-condensing or a condensing engine. The former is the most simple, and at its first cost the most economical: the latter, though more expensive, is the more perfect, though never used in the practice of the farm. The engine, according to the size of the farm, should be equal to a six or eight horse-power. The steam-engine for the thrashing-machine has now come into general use in the north of England and south of Scotland, where the farms are generally of the larger class.

Thrashing-machines driven by hand-labour have been often recommended, and in some cases constructed. But the machines of this class appear to possess no advantage over the flail, or rather to be much inferior to it with respect to economy of labour.

(2.) *WINNOWING-MACHINE.*

The winnowing-machine is designed to remove the husks or chaff of corn from the grain, and to separate the impurities and loose refuse intermixed. With certain variations in the form of its parts, the principle of construction of this machine is, in most places where it is used, the same.

Four or more oblong boards of wood are fixed, at equal distances from one another, upon an axle placed horizontally, and extending through the machine. This axle is driven round by a wheel acting upon a pinion, so that a rapid rotatory motion is given to the boards, and a current of air by this means produced. The corn to be winnowed is made to fall from a box or hopper, in the course of this current, through one or more sieves of wire, which, being kept in a quick lateral motion, intercept and scatter the grain, while the current of air acts in blowing away the chaff. The chaff being separated in this manner, the heavy grain falls down and is collected.

Fig. 47.

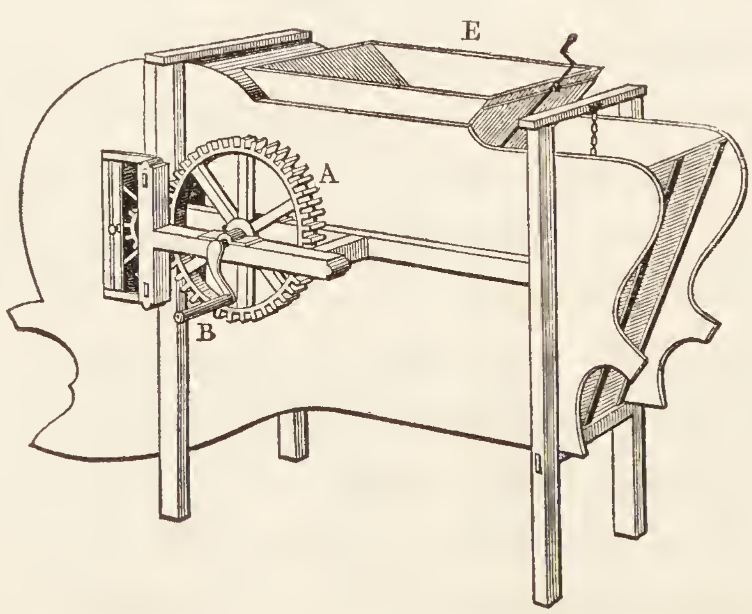


Fig. 47 represents one side of the machine. E is a hopper into which the corn is lifted. A is a wheel driven by the handle B, and this wheel acting upon a pinion, gives motion to an axle,

on which are placed four oblong boards. To these boards, which are enclosed nearly all round, air is admitted from open spaces on both sides of the machine, as shewn in the figure. These spaces may be enlarged or diminished by means of sliding boards, so that a larger or smaller quantity of air can be admitted.

Fig. 48 is the opposite side of the machine, and the occult lines represent a section of the interior. Here DDDD are the four oblong boards, termed fanners, by the rapid motion of which in the direction of the arrow *xxxx*, a strong current of air is produced through the interior of the machine in the direction of the arrows *yy*. E, shewn also in Fig. 47, is the hopper, into which the corn to be winnowed is put. The corn falls down from the hopper upon the sieves HI. These sieves are connected with the bottom of the hopper FG, which is moveable, and fixed to a hinge at K, and hung on two chains, one of which L, is seen in the

Fig. 48.

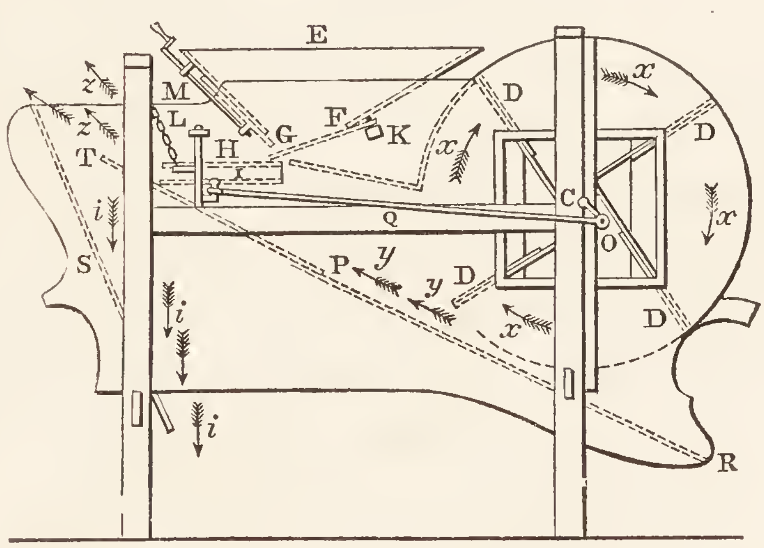


figure. When the motion, therefore, is given to the sieves HI, motion is at the same time given to the board FG, which forms the lower part of the hopper. The shaking motion given to this board causes the corn in the hopper to fall through upon the sieves by the aperture at G. By means of the screw M, a sliding board is made to be raised or pushed down, so that a greater or less aperture shall be left at G. The lateral or shaking motion is given to the sieves and bottom of the hopper by means of the rod Q, which is connected by one crank with the sieves, and by another crank O, with the axle C, to which the fanners are attached. The bottom

of the machine TR, formed of boards, is placed obliquely, so that the corn, after having passed through the sieves, shall fall along the inclined plane from T to R. A part of this bottom is perforated like a sieve, so that dust, sand, and other impurities, shall be separated from the corn as it falls from T to R. A portion of this bottom also PT is made to slide. A board S, extending across the machine behind, is made to slide up or down, and all the space *zz* is open.

The manner in which the machine acts will now be understood. A person drives the handle, and so gives motion to the fanners within. The corn to be winnowed is lifted up, placed in the hopper, and continually supplied as it falls through. It falls through the aperture G, which it has been seen can be enlarged or diminished, upon the two parallel wire-sieves HI. In the mean time, the current of air acting upon it, the chaff is blown out at the end of the machine in the direction of the arrows *zzz*. The heavy corn falling down the inclined bottom comes out at R. Should any of the corn be so light as to be blown past the point T, but yet not be sufficiently light to be blown away with the chaff, it falls down in the intermediate space in the direction of the arrows *iiii*, separately from the heavy corn. By pushing upwards the sliding board PT, a smaller quantity of this lighter corn is separated, or, in other words, a larger portion of it falls down mixed with the heavy corn. By elevating the board S, a smaller quantity of lighter corn is blown away with the chaff.

There are differences in the form of this machine. Thus in place of two sieves, one above the other, one may be rendered sufficient. The heavy corn, in place of falling out at the end at R, may be made to fall out at a spout at the side; and, in like manner, the light corn, in place of falling down below the machine, may be discharged by a spout. This is the construction adopted when the machine is attached to the thrashing-machine. Sometimes the bottom PR is made moveable, so that a shaking motion may be given to it for the better causing of dust and sand to fall through. The machine when not attached to the thrashing appa-

ratus, is made so light as to be readily moved from one part of the barn to the other.

5. Implements for Preparing Food for Live Stock.

In many cases, it is beneficial to prepare the food to be used by the animals of the farm in various ways. The first to be mentioned of the class of implements employed for this purpose, is that for cutting the roots of turnips and other plants into pieces, that they may be the more readily eaten by sheep and oxen.

(1.) *TURNIP-SLICER.*

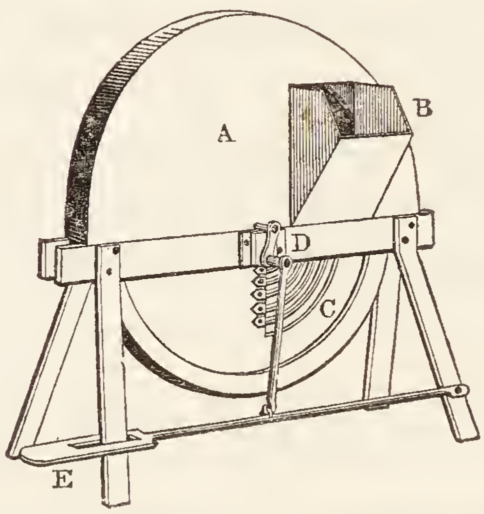
Various machines have been constructed for this purpose. The most common and simple is that formed by means of knives placed upon a wheel, and made by each revolution to cut slices from the turnip or other roots. The wheel, covered with boards, is set upon a framework, and a box or hopper, open on the side next the wheel, is so placed, that, when the roots are put into it, they press upon the side of the wheel. At every revolution of the wheel, each of the knives makes a stroke upon the roots, which are pressing upon the wheel at the open side of the hopper, and cuts off a slice; and the machine is so formed that the cut pieces shall fall from the hopper to the ground, or into a basket or other vessel.

This machine is exceedingly well adapted for cutting the roots of turnips and mangel-wurzel for oxen. But when sheep, and especially young sheep, are to be fed in spring, and when their teeth are loose, it is often better to cut the roots not only into slices, but to divide them into smaller pieces still, that they may be the more readily taken up by the animals. The machine described may be easily made to cut the roots in this manner, by having two sets of knives or cutters, placed at right angles to one another, so that the roots which are pressed against them

shall be cut in two directions, and thus divided into pieces, of greater or smaller size, according to the distance at which the knives are placed from one another.

The following figure represents a machine of this kind. A is

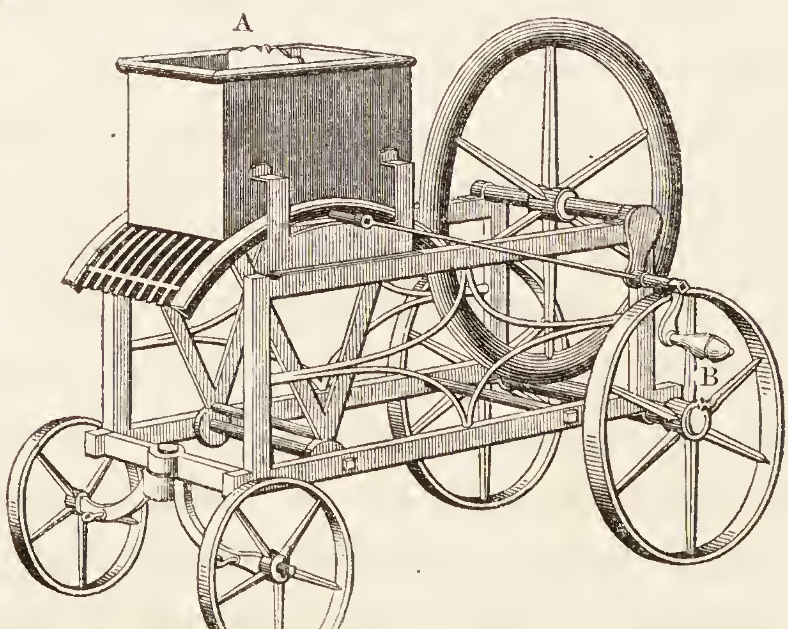
Fig. 49.



the boarded wheel, B the hopper open at the top and the side next the wheel, in which the roots to be cut are put, C a portion of the cutting apparatus, D the handle by which the wheel is driven, and to aid the action of the hands may be added a treadle E.

The following figure represents a machine for the same purpose, in which in place of the boarded wheel, the knives are at the bottom of a hopper A, and have a reciprocating motion

Fig. 50.



given to them by the handle B. The machine, for the facility of carriage, is placed on wheels, and may be formed altogether of iron.

Fig. 51.

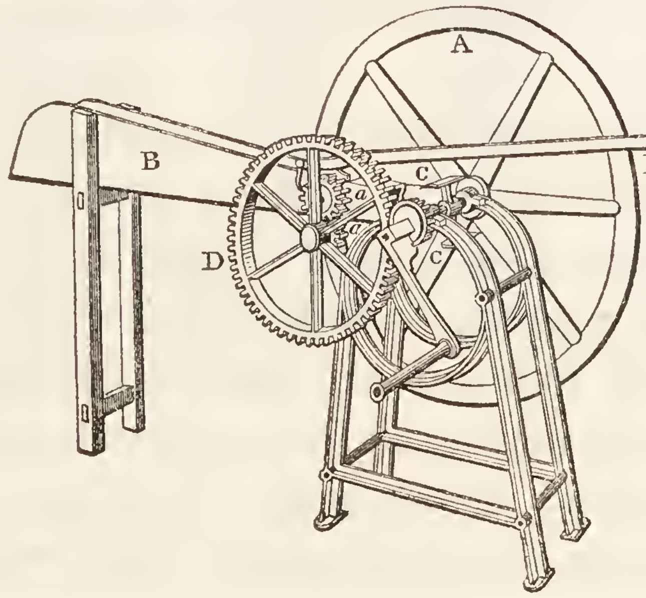
A common mode of cutting turnips into pieces for cattle is by an instrument (Fig. 51) with four blades at right angles to one another. The turnip or other root is struck as it lies upon the ground, or in the feeding-trough, and thus at one stroke is divided into four parts.

(2.) *CHAFF-CUTTER.*

The chaff-cutter is a machine employed for cutting hay and straw into pieces of a given length. By this process, it is found that the dried stems of plants can be more easily consumed by cattle, and, therefore, afford more nourishment in a given time.

In this class of machines, the hay, straw, or other substances to be cut, are placed in a narrow oblong trough. They are then pressed forward to two revolving cylinders, which hold them with firmness, and gradually carry them onward. As portions are protruded by the cylinders they are acted upon by one or more knives, sometimes placed upon a fly-wheel or its axle, and sometimes on another wheel, to which motion is conveyed from

Fig. 52.



the fly-wheel. The desiderata in the construction of these machines, are, 1*st*, causing the knives to make the cut in the most efficient manner, which is by a draw-cut, and not by chopping, and is done by placing either the knives or the substances to be cut in an oblique position; and, 2*dly*, causing the substance to be brought forward to be acted upon by the knives with regularity, and so adapting this action to the several strokes of the knives as to vary the length of the cut according to the degree of fineness to which it is wished to reduce the stems.

The foregoing figure represents a machine formed with a regard to these principles. Upon the axle of the fly-wheel A are fixed arms, carrying the knives CC; and B is the trough in which are placed the straw and other substances to be acted upon. These are brought forward by two fluted cylinders, to which motion is given by the spur-wheel D and pinions *a a*, the wheel D being itself driven by a pinion fixed on the axle of the fly-wheel. As oblique knives are expensive to be kept in repair, the box B through which the material to be cut is protruded, has its underside formed so as to act with the knife in the manner of scissors, and it is curved in such a manner that the knife-edge, which is straight, makes a draw-cut, or comes successively in contact with the different portions of the materials to be acted upon. E is a lever pressing the fluted cylinders together, so as to regulate the force with which they hold the material to be cut.

(3.) *MACHINE FOR BRUISING GRAIN.*

A machine is used occasionally for bruising seeds, as of pease, beans, or oats, intended for the food of animals, and thus rendering the mastication more perfect. There are different forms of these machines. They are sometimes driven by the hand, though this is better done by a power attached to the thrashing-machine, or where this is not convenient, by a single-horse power. Perhaps the best construction of this class of machines is that of two plane rollers of large diameter, kept in rapid motion, the corn to

be bruised being supplied from a hopper, so as to pass between them.

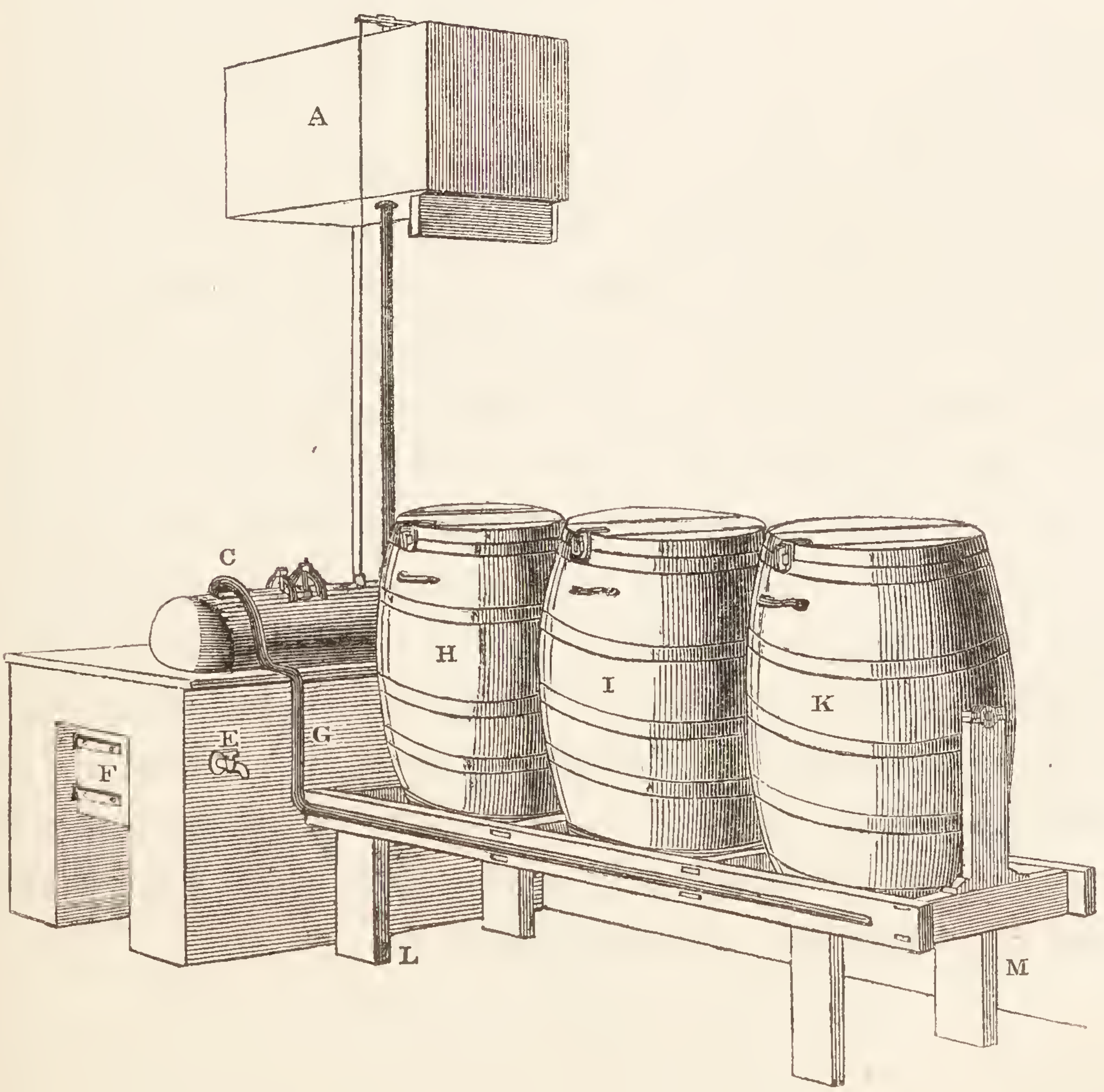
The machines driven by the hand are convenient, as being portable; but the labour of driving them is considerable, and all the purposes of such machines may be served by having the seeds coarsely ground in any common corn-mill.

(4.) *APPARATUS FOR BOILING OR STEAMING FOOD.*

In numerous cases it is found to be beneficial to boil roots and grain before they are given to animals. The most economical method of preparation is by heating the water by means of steam, conveyed from the boiler to the vessel containing the roots or grain.

Any kind of wooden box or barrel will answer for this purpose,

Fig. 53.



so formed as to admit of being readily filled and emptied. The steam is to be conveyed in a pipe to the lower part of the vessel, which ought to have a sliding board at the bottom to allow the contents to be discharged when ready. The vessel may be filled with water, though this is not necessary in the case of succulent roots as the potato, because the steam is quickly condensed. But when corn is to be boiled, it should be covered with water, that the steam may be condensed.

The foregoing figure represents a steaming apparatus of a sufficiently good construction.

A is a cistern for containing water, and supplying it to the boiler C. The boiler is furnished with water and steam-cocks, for ascertaining the quantity of water within, and with a float, the wire from which communicates with the cistern, and regulates the supply of water. A pipe may proceed from the boiler to the outside of the building in which it is contained, and have a stop-cock E to draw off hot water. F is the boiler-furnace, and G is the steam-pipe proceeding from the boiler, and communicating, by means of branch-pipes, with the barrels H, I, K. These barrels are suspended in gudgeons between the uprights of the frame or gauntree LM, the point of suspension being a little above the centre of gravity of each barrel. Each barrel is furnished with a perforated false-bottom, between which and the true bottom the branch steam-pipe is inserted. This branch-pipe is connected with the steam-pipe G by a spigot and faucit joint, and the branch to each barrel has a stop-cock, by which the steam may be cut off from any barrel. The food to be steamed is introduced into the barrel by the top, which has a hinged lid, fastened by a screw, and when the food is ready, the steam is cut off from the barrel, and the barrel is turned round its centre, until it lies in a horizontal position on the edge of the gauntree. The food is then emptied into a wheelbarrow or cooling trough, and the barrel is allowed to regain its vertical position.

6. Wheel-Carriages.

The carriages employed by the farmer are moved either by hand-labour, as in the case of barrows of different kinds, or by the working cattle of the farm.

The carriages of the latter class are either carts on two wheels, or waggons on four. Those of either kind have their advantages, and in certain kinds of work each may excel the other.

When the object is the conveying of heavy and bulky substances, as hay and corn, the waggon has this advantage, that a greater number of animals can be employed to move one load.

No waggon, however, for the purposes of the farm, ought to require a greater force of draught than two horses; and in order that the horses may exert their force in the most advantageous manner, they should be yoked abreast, and not one before the other, according to the common practice. They should be so attached, too, as that each, pulling upon the collar of the other, should exert an equal force in drawing. In order that the waggon may turn with facility, the fore-wheels are generally made considerably smaller than the hind-wheels, as we see in coaches and chariots, so that they may turn below the bottom of the carriage. By this diminution of the size, however, the force required to draw the waggon is increased, both by the comparatively greater friction on the axle of the smaller wheel, and by the greater difficulty of pulling it over obstacles. For these reasons, the fore-wheels should either be kept as large as is consistent with the facility of turning, or placed a little in front of the body of the carriage, so that a smaller proportion of the weight shall press upon them. It is an improvement to have a drag, formed by making a bar of wood bear against the periphery of the wheels, by means of screws working through the back-bar of the carriage. In this way, the driver has the waggon under his control in descents, more effectually than by means of the chain commonly used.

The waggon may also be used with a single horse; and some

who have employed the single-horse waggon, prefer it to other carriages for the purposes of ordinary draught.

Although the waggon, under certain given circumstances, possesses advantages of its own, it is yet inferior to the single-horse cart for the more common purposes of the farm.

In the single-horse cart, the horse partly bears the load and partly drags it. In this manner, it is believed that it can be shewn that the horse can move a greater weight, at least for moderate distances, than when he exerts his force solely in pulling. The single horse-cart, therefore, in this excels the waggon, that for moderate distances, a greater comparative weight can be drawn by an equal exertion of animal force. And it possesses this further advantage over the waggon, that it is more readily turned, backed, and otherwise managed, so that a considerable saving of time is effected by employing it in most of the common operations of the farm.

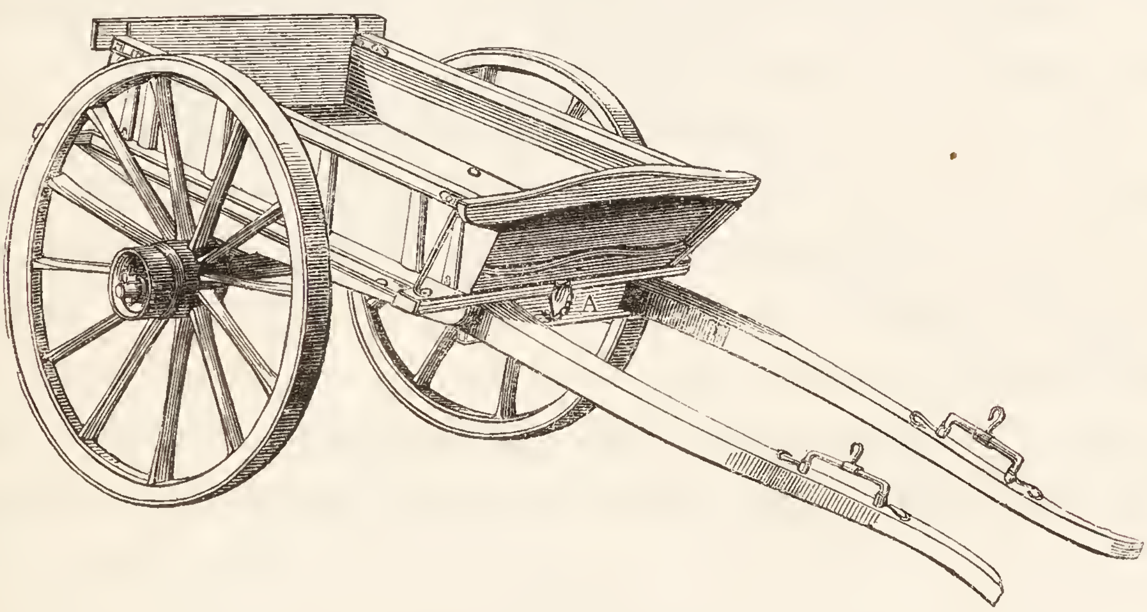
The objections to the use of the cart for the carriage of loads exist when the roads are bad, and the carriages very distant. In either case the horse is distressed by the pressure of the load and his own confined position in the shafts: but, where the roads are good, this objection does not apply; and experience shews that a greater weight can be drawn for an equal distance by the same number of horses in carts than in waggons of the common construction.

But two horses may be employed to draw the cart, one being yoked before the other. In this case, however, a considerable loss of power results from the manner in which the fore-horse is necessarily attached to the carriage: for, by ceasing to exert his force even for the shortest time, he throws the whole burden upon the shaft-horse; and when, after a temporary relaxation of draught, he makes an exertion, it is effected by means of a start or jerk, which distresses himself as well as the shaft-horse; and as he frequently pulls in a line of direction somewhat different from that of the shaft-horse, a part of the force exerted is lost, and becomes a pressure upon the back of the latter. Hence, although the fore-

horse frequently throws the whole labour of draught upon the horse behind, yet, by exerting his force solely in pulling, without bearing any portion of the weight, and by the starts and jerks to which he is subjected, he is almost always found to be more distressed on a journey, or by any continued work, than the horse on which the burden falls more constantly and equally.

The following figure represents the single-horse cart; but the same form of construction is adopted when two horses are employed. This is termed the close-cart, in contradistinction to the other, to be afterwards described, employed in the carriage of hay, corn in the straw, and other bulky articles, and usually termed the corn-cart.

Fig. 54.



The body of the close-cart may be fixed to the shafts, or so formed as to be raised independently of them, when it is termed a turn-up cart. It is made in this manner, in order that the body may be raised so as to discharge the load from behind. The body turns upon the axle, and is kept attached to the shafts by a hook at A. The hook being disengaged, the body of the carriage may be lifted up, the horse remaining in the shafts. When this method of construction is not adopted, but when the body is fixed permanently to the shafts, it is necessary, when loads are to be discharged behind, that the horse be disengaged from the shafts and the whole lifted up. This appears to be very awkward, and yet in practice it is found to be attended with no inconvenience.

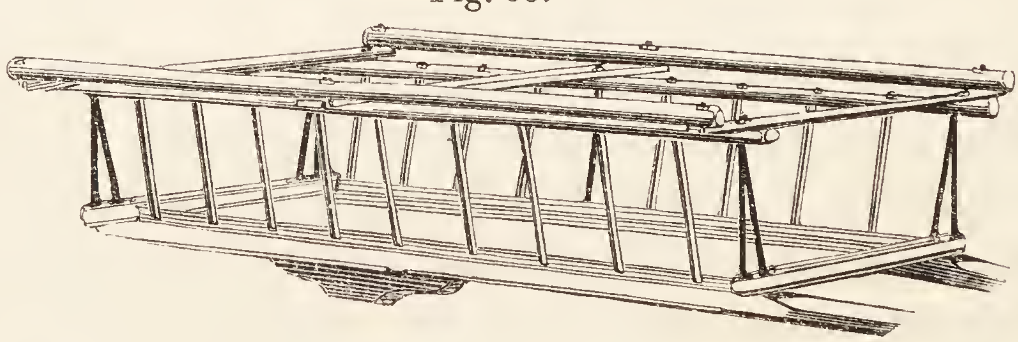
The carter, by taking hold of the end of a shaft, has a more powerful lever to elevate the cart than in the case of the turn-up cart, while the cart itself is made more light and compact: and with respect to unloosening the horse in the shafts, this is done in a time almost as short as in elevating the turn-up cart.

In every cart the hinder board is made to be detached for the purpose of discharging the load, or placing it more easily in the carriage. Two boards, removable at pleasure, may be placed one upon the edge of each side of the cart, for the purpose of better supporting the load when bulky. They are fixed by long handles passing through iron staples on the outside of the cart.

In using the single-horse cart in journeys, one man drives two carts. The horse of the last cart is fastened by a rope from his bridle to the cart before; and he soon learns to follow steadily and quietly in the same track.

The other form of the cart is that represented in Fig. 55. This species of cart is sparred at the sides, and is formed in this manner for the purpose of carrying loads of corn in the straw, hay, and similar bulky commodities. It is generally made of such dimensions as to be drawn by two horses, one yoked before the other. The reason of this is, that, from the nature of the load, one man can drive only one cart, so that, if one man, by the prac-

Fig. 55.



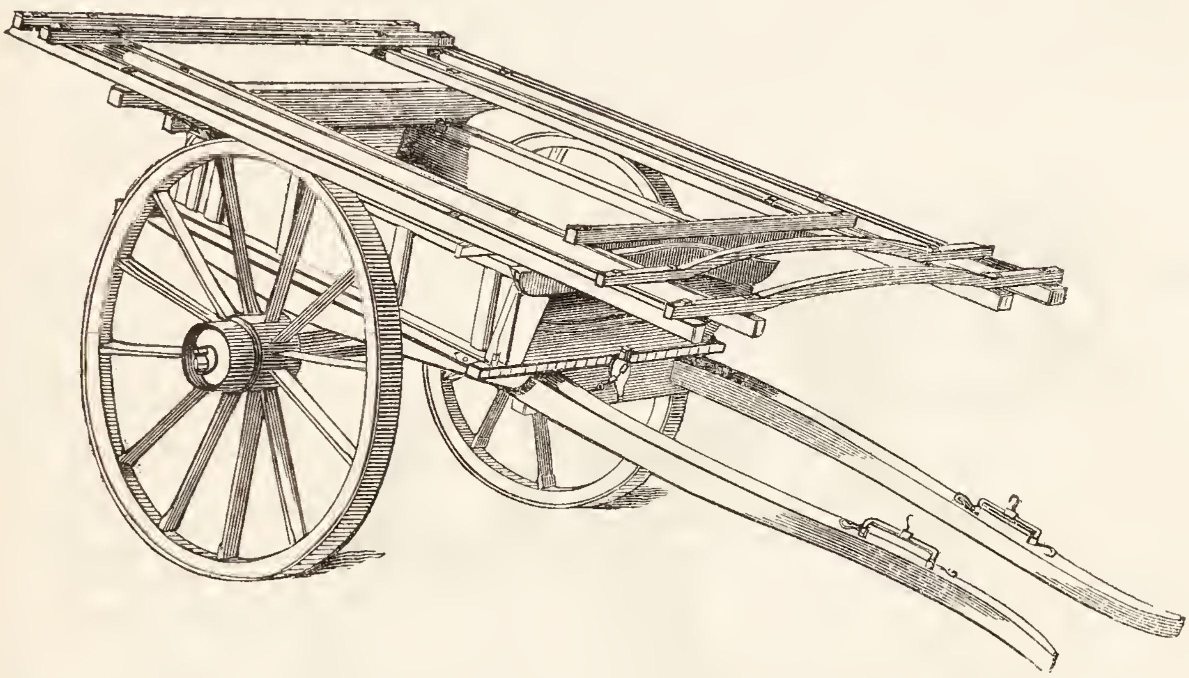
tice of the farm, has two horses, an additional person will be required for driving the second cart. For this reason, it is generally thought better that two horses should be used, though to a disadvantage as to the power of draught.

Where this practice prevails, it is not necessary that there be a separate axle and wheels for the cart. It is only used occasion-

ally, and is placed upon the axle and wheels of the close-cart. Thus, the simple arrangement is, when hay and the like are to be carried, the close body is removed, and the sparred one placed upon the same wheels.

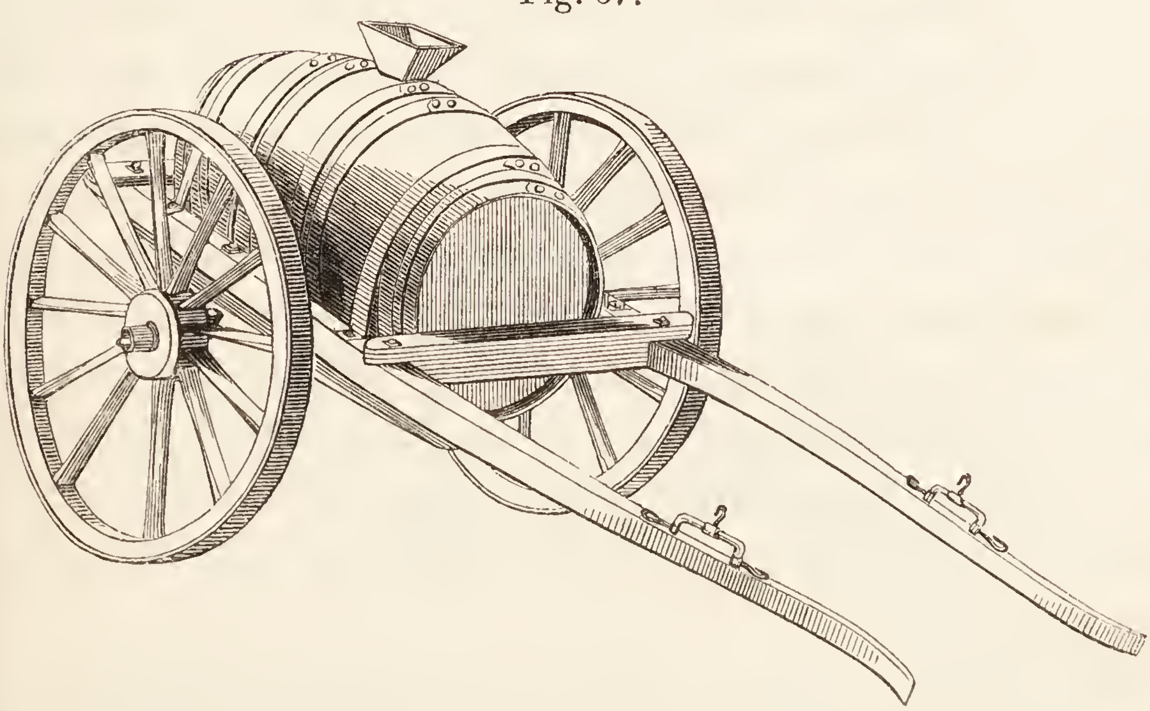
It is very convenient to have a sparred frame to be attached to the close-cart. By this means, when occasion requires, it may be employed for the same purposes as the larger sparred or corn-cart.

Fig. 56.



It is often convenient and necessary upon a farm to have a carriage for the conveyance of water. This may consist of a large barrel, placed upon the frame of a common cart; and in order that the barrel may not be too high, the axle may be bent.

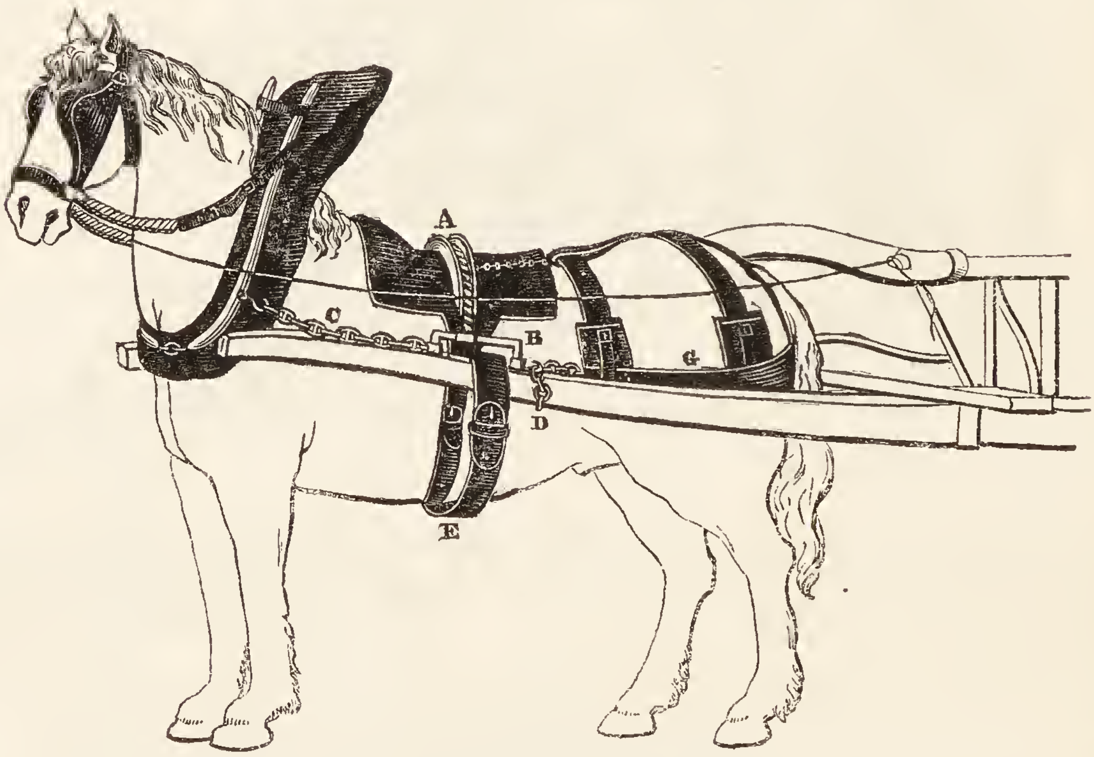
Fig. 57.



The manner in which the animals of draught are attached to these carriages is very simple.

On the back of the shaft-horse, Fig. 58, is placed the cart-saddle; which is formed with a raised groove A, over which a chain, to be attached to the shafts, passes. This chain is fixed on each side to a hook moveable along an iron staple B, fixed upon the shafts. To the same staple are fixed two other hooks. To one of these is attached a chain C, which is fixed to the collar of the animal, and by means of which he exerts his force in pulling: to the other hook is fixed the breech-chain D, attached to the leather

Fig. 58.



belt G, by means of which the horse is enabled to resist the descent of the load when going downhill, and to back the cart. Thus, to the iron staple there are attached the collar or draught-chain, the back-chain and the breech-chain. A band E then passes beneath the horse from shaft to shaft, which prevents the shafts from being raised up by the weight of the cart. The bridle of the horse is a single snaffle, to the rings of which, on each side, are fixed the reins by which the driver guides him. These reins pass through rings upon the collar. When the horse is to be unyoked, the bellyband is unloosed, and the collar and breech-chains are unhooked.

When another horse is used, he is yoked by chains fixed near the ends of the shafts; and, to keep the chains asunder, a bar or

stretcher is fixed between them. The trace-horse has no cart-saddle, having no weight to bear upon his back, and he has no breeching, since he has no power of backing or resisting the descent of the draught. A band, and sometimes two, pass over his back to support the chains. A band also passes beneath his belly to keep the harness in its place. The chains are attached to the collar. The bridle, as in the case of the shaft-horse, is a snaffle, to the rings of which are attached the reins.

7. Utensils of the Dairy.

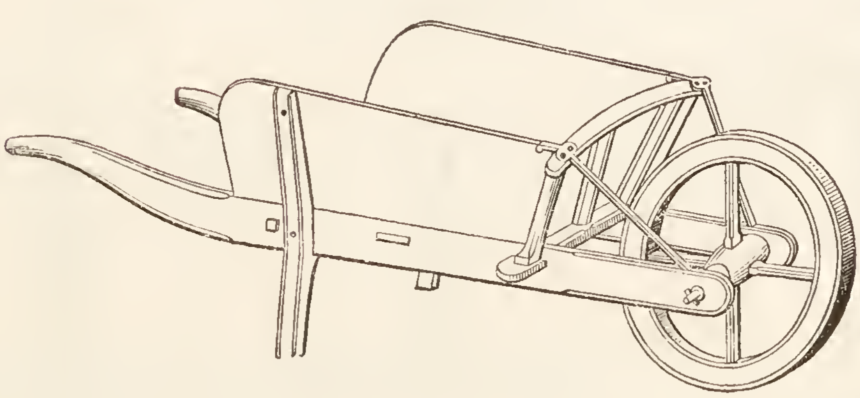
The utensils required for the dairy consist of vessels for containing milk, of churns, of cheese-presses, &c. These form a class which will be most conveniently treated of when describing the works of the dairy.

8. Implements of Manual Labour, &c.

These form a numerous class; but it will be here necessary to refer to only a part of them. The remainder will be more conveniently described when reference is made to the labours in which they are employed; and an enumeration of the whole which are necessary upon a farm will be given under the head Capital.

(1.) *WHEELBARROW.*

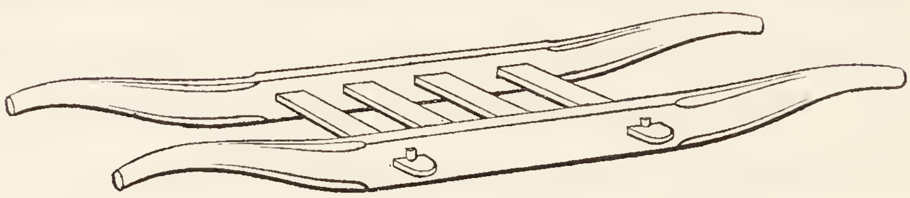
Fig. 59.



The wheelbarrow is employed for the carriage of light loads, as of earth, for short distances, lime for building, and the like.

(2.) *HANDBARROW.*

Fig. 60.



This species of barrow is, under certain circumstances, substituted for the wheelbarrow, for short distances.

(3.) *SPADE, BROAD-POINTED SHOVEL, AND NARROW-POINTED SHOVEL.*

Fig. 61.

Fig. 62.

Fig. 63.

The spade here shewn, Fig. 61, is the common spade: the broad-pointed shovel, Fig. 62, is chiefly used for the spreading of lime: the narrow-pointed shovel, Fig. 63, for the throwing out of loose earth from ditches, furrows, and drains, and for various other purposes in conjunction with the spade.

(4.) *MATTOCK, PICKAXE, AND FOOT-PICK.*

Fig. 65.

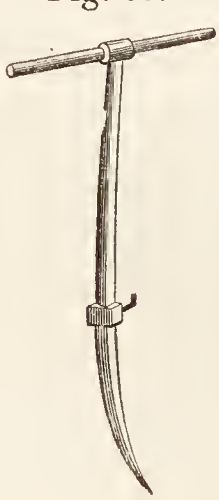
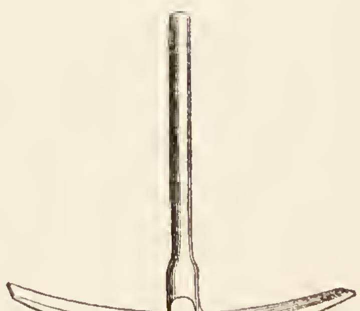


Fig. 66.

Fig. 64.



The mattock, Fig. 64, is used for forcing up stones, breaking hard ground, and the like: the foot-pick, Fig. 65, is employed for similar purposes: and the pickaxe, Fig. 66, is made for cutting substances, as the fibres of the roots of trees, as well as for forcing them up.

(5.) *SAW, AXE, SLEDGE, AND HAMMER.*

Fig. 67.

Fig. 68.

Fig. 69.

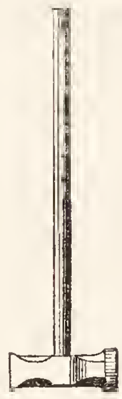
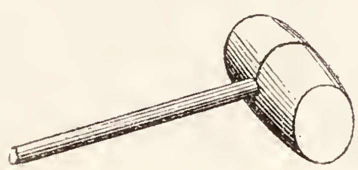


Fig. 70.

These implements differ in nothing from similar tools in common use.

(6.) *MALL.*

Fig. 71.



The mall is employed for driving posts, piles, and the like, into the ground.

(7.) *DUNG-FORKS.*

Fig. 72.

Fig. 73.

The larger fork, Fig. 72, of this class is used for the lifting of dung into carts, &c.: the small fork, Fig. 73, chiefly for the spreading of dung upon the ground.

(8.) *FORKS, LONG AND SHORT.*

Fig. 74.

Fig. 75.

Fig. 76.

The forks of this class differ from the last in the uses to which they are applied: Fig. 74 is used for forking straw and other substances to a height; Fig. 75 for forking the sheaves of corn into carts or waggons; and the smaller fork, Fig. 76, is used in the stable, and for numerous purposes.

(9.) *HAY-RAKE.*

Fig. 77.

The hay-rake is employed in raking the surface of ground, for the purpose of collecting loose hay, straw, stalks of corn, &c.

(10.) *HAND-HOE.*

Fig. 78.

The hand-hoe is employed in the cultivation of turnips, potatoes, and other plants.

(11.) *SCYTHE.*

Fig. 79.

The scythe is used for mowing hay, green forage, corn, and the like.

(12.) *DUNG-DRAG, AND MUD-SCRAPER.*

Fig. 80.

Fig. 81.

The dung-drag, Fig. 80, is used chiefly for the dragging of dung from carts : the mud-scraper, Fig. 81, is used for collecting substances on the ground, as mud, dung, &c.

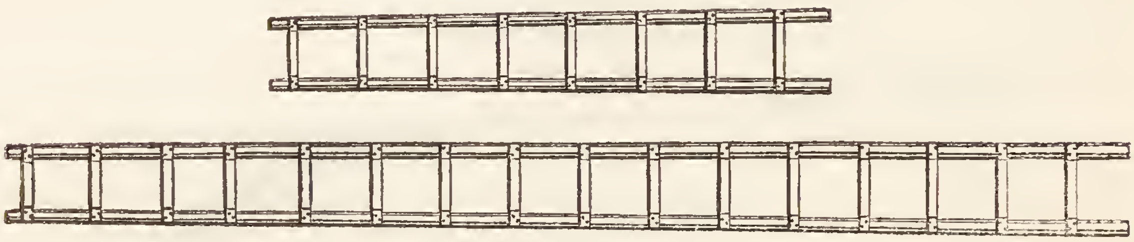
(13.) *HAY-KNIFE.*

Fig. 82.

The hay-knife is employed for cutting off portions of hay from the compressed mass of the hay-stack.

(14.) *LADDERS, LONG AND SHORT.*

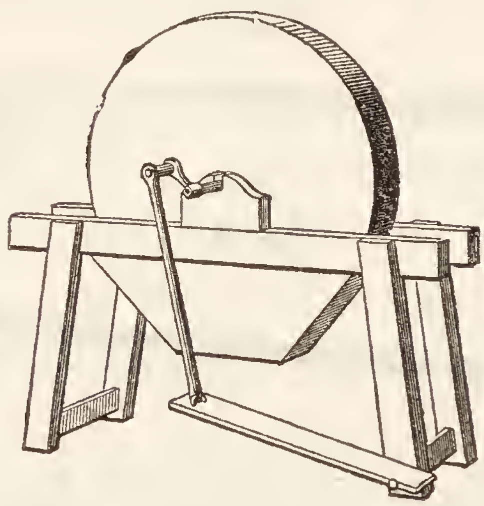
Fig. 83.



The ladders of the farm are of different sizes, according to the uses to which they are applied: they may be of the respective lengths of 24, 16, and 8 feet.

(15.) *GRINDSTONE.*

Fig. 84.



The grindstone is best made to be moved by the foot, and may have a trough beneath, in which water is to be put to keep the stone moist when working.

(16.) *UTENSILS OF THE STABLE,—CURRYCOMB, BRUSH, MANE-COMB, FOOT-PICKER, AND SCISSORS.*

Fig. 85. Fig. 86. Fig. 87. Fig. 88. Fig. 89.

(17.) *WEIGHING MACHINES.*

A common balance for weighing wool and similar substances is necessary upon a farm; and sometimes other weighing machines, and particularly one for weighing large loads, as hay.

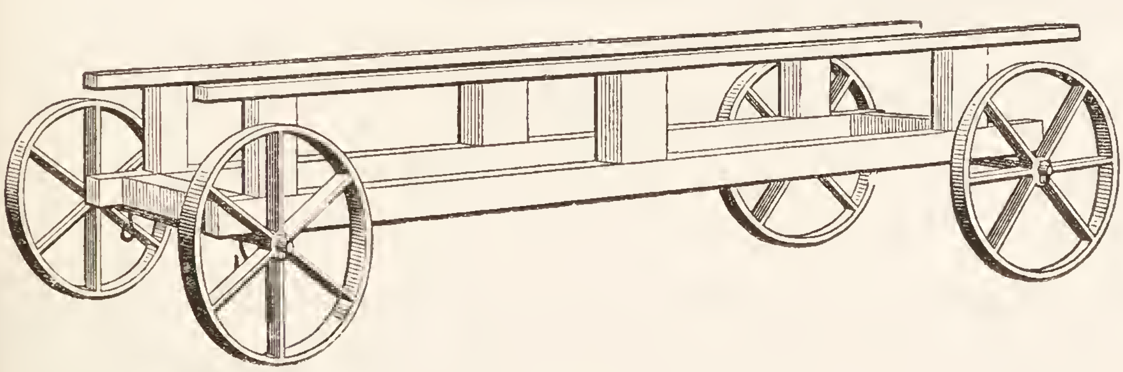
18. The utensils of the Barn will be afterwards described.

19. The Hedger's Tools will be described when the operations in which they are employed are treated of.

20. There is a mixed class of implements, consisting of pails, &c., which need not be represented. They will be enumerated under the head Farming Capital.

It is often convenient to have upon a farm a truck, with four low wheels, for the purpose of carrying ploughs, harrows, and other implements, along roads.

Fig. 90.



IV. SIMPLE OPERATIONS OF TILLAGE.

1. Ploughing.

In ploughing, it has been seen, a slice of earth is to be cut from the left-hand side, and to be turned over to the right-hand side. In this operation, the left-hand or near-side horse walks on the ground not yet ploughed, the right-hand or off-side horse walks in the furrow last made, and the workman follows in the furrow in the course of being turned over, holding the handles of the plough. By means of these handles he guides the plough, and he directs the animals of draught by the voice and the reins. When he is to turn the plough at the end of a ridge, or when it encounters an obstacle, as a large stone, he presses down the handles, so that the heel of the plough becomes a fulcrum, and the share is raised out of the ground.

In ploughing, the instrument ought to be held nearly vertical. If it is inclined to the left-hand side, the same work is performed in appearance, though not in reality; a portion of the ground below not being tilled at all, but left thus—

Fig. 91.

The plough is of the most perfect form when its various parts are so adjusted that they shall not oppose one another's motion; but it is very difficult to form a plough that is perfect in the form and combinations of its parts. Even in those of the best construction, there is frequently found to be a tendency to rise out of the ground, or to turn to one side, generally the right-hand or open side. The tendency to rise out of the ground can be corrected by giving an inclination downwards to the point of the share; and the tendency to turn to the open or right-hand side can be obviated by turning the point of the share slightly to the

left-hand side. By these means, however, the labour of draught is increased, and care must therefore be taken, that this tempering of the irons, as it is frequently called, be not in any case carried further than is necessary to correct the defects of the instrument. All that is necessary beyond this is effected by changing the position of the line of draught by means of the bridle on the beam.

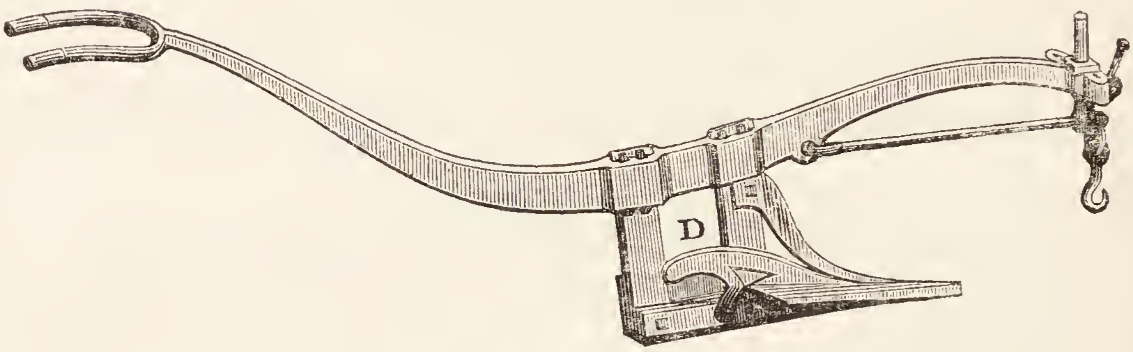
With regard to the depth to be ploughed, this, we shall see in the sequel, depends upon the kind of crop to be cultivated, and other circumstances. It has been shewn that a furrow-slice of ten inches in width requires a depth of seven inches, that is, a depth of about two-thirds of the width, in order that it may lie at an angle of 45°. But although it is proper to proceed on this principle in forming a plough, we cannot regulate the depth to the width in this manner in practice. It is not necessary that the depth should be to the width in the proportion of two to three, or that the sods should lie precisely at an angle of 45°. In the field, all that can be arrived at is a kind of approximation to the true proportions. When the sods are considerably too wide in proportion to their depth, the ploughman will be admonished of this by their lying too flat, and too slightly overlapping one another. When their depth is considerably too great in proportion to their width, they will stand too upright, and be apt to fall back again into the furrow.

The medium depth of good ploughing may be held to be seven inches. When circumstances, as the kind of crop and the nature of the soil, do not require deep ploughing, the depth may be less: but it will be considerably more in those cases, to be afterwards adverted to, where deep ploughing is from any cause expedient.

Often it is beneficial to give a deeper ploughing to land than the ordinary depth of furrow. This may be effected by what is termed trench-ploughing, in which one plough follows in the track or furrow of another; by which means the land may be tilled to the depth of 14 inches, or more. Sometimes the ploughs which follow the others are deprived of their mould-boards, and sometimes a kind of plough is used, designed expressly for this kind of

work. One of these, improved by Mr Smith of Deanston, is formed wholly of iron, weighs about 4 cwt., and requires the active force of

Fig. 92.



four horses. It has a stout share, but no mould-board. Rising from the share, and parallel to the body of the plough, is a flat piece of iron D, the use of which is, that, when the plough is struck by stones, they may be forced upwards by means of the inclined plane which the piece of iron presents. This is an efficient instrument, designed especially to break the subsoil, and hence it has been termed a subsoil plough. It performs, however, in part, the office of mixing a portion of the subsoil with the upper stratum, which is one of the ends of trench-ploughing. Much has been recently written on the value and uses of subsoil-ploughing, as it has been termed, or merely stirring the subsoil, without bringing it to the surface. Advantage will result in most cases from deep tillage, and in all cases from breaking a hard subsoil impervious to water; but it is always better that the latter be brought wholly or partially to the surface, so as to be acted upon by the air. Trench-ploughing, therefore, is superior, as a permanent improvement of land, to subsoil-ploughing, when the latter is solely confined to the breaking of the subsoil. A modification of the instrument represented above, is to reduce the weight, so that it may be worked by two horses, and support the beam by a wheel.

In the moist climate of this country, and indeed of most others in Europe, it is common to form the ground into what are termed ridges, so as to admit of the water which falls upon the surface finding a ready egress. And even in lands so dry that little injury will result from stagnant water, such ridges are generally

formed on account of their convenience in the different works of tillage.

The first operation in the forming of ridges, is *striking the furrows*.

Let it be supposed that the field has been laid level by previous ploughings, and that the marks of former ridges being obliterated, the lines of the new ones are to be laid out. The usual breadth of ridges is from 15 to 18 feet, and sometimes more. We may assume, in the following descriptions, 15 feet to be the width of the ridges.

Let a steady ploughman be furnished with three or more poles of wood, shod with iron, 8 or 9 feet in length, and divided into feet and half feet. The first operation is to mark off, at two sides of the field, what is termed a head-land. This is merely a ridge formed parallel to the sides of the field on which the horses are to turn, to afford sufficient space for which, these ridges may be 16 or 18 feet wide. The lines of them are marked off before the other ridges, in order that the ploughman may know, on arriving at the end of the ridge, when to turn his horses. After the rest of the field is ploughed, the head-lands themselves are ploughed, and formed into ridges.

In the following diagram, representing a field, let EF, GH, represent the lines of the head-lands, drawn parallel to AB and CD, the sides or boundaries of the field, and at the distance, from each of these sides, of 16 or 18 feet. These lines the ploughman marks out, by running a straight furrow with his plough parallel to the two sides.

Let him now, beginning at the side of the field AD, parallel to which it is intended to run the ridges, measure off with his pole E a, $7\frac{1}{2}$ feet, or half the breadth of the ridges to be formed. At the point a let him place one of his poles. This is the point at which he is to *enter* his plough. But, leaving his horses in the mean time, let him walk on to a convenient distance, as to I, and there, in like manner measuring off I b, $7\frac{1}{2}$ feet, let him set up his second pole at b, and then, at the further end of the field, on the

line of the head-land at *c*, let him place his third pole. He has now three poles placed in a line; but if, from the length of the field, or inequalities of the surface, more than three poles are necessary, more must be used, as there must be so many poles in sight as that the ploughman may be enabled to direct his plough by means of them in a straight line. He now returns to his plough, and enters it at the first pole at *a*, keeping the other two poles in a line, so that he may be enabled to plough directly towards them. Having entered his plough at *a*, he stops his horses, and measures off 15 feet, or the breadth of a ridge, to *d*, where he plants the pole. He then returns to his plough, which is standing at *a*, and drives his horses, keeping the two poles before him as a guide, to the second pole *b*. Having done this, and leaving his plough standing at *b*, he measures off from *b* to *e*, 15 feet, and there he plants his pole. He then returns to his plough, and proceeds forward, making his furrow in a straight line to the last pole *c*, where, in like manner, he stops his horses, and measuring off 15 feet, he plants his pole at *f*.

In this manner he has placed his poles in a straight line, at the distance of 15 feet from their last position, and parallel, as before, to the line of fence. He now turns his horse sharp about, and returns by the furrow which he had just drawn *c b a*. By this second ploughing, he throws the earth out in an opposite direction, so that he has formed a completely open furrow. In returning, he takes care to correct any inequality or crookedness that may have taken place, through the unsteady motion of the horses, in his first track.

The poles being now placed in a line, *d e f*, he brings his plough to *d*, enters it and stops it there. He measures off 15 feet with his pole from *d* to *g*, and fixes his pole at *g*; and then he proceeds with his plough to *e* and *f*, repeating the same operation with his pole as before, and returning by the track of his last made furrow from *f* to *d*. In this manner he proceeds throughout the whole field forming parallel open furrows, at the distance from one another of 15 feet. These furrows are to form the *centres* of the future ridges.

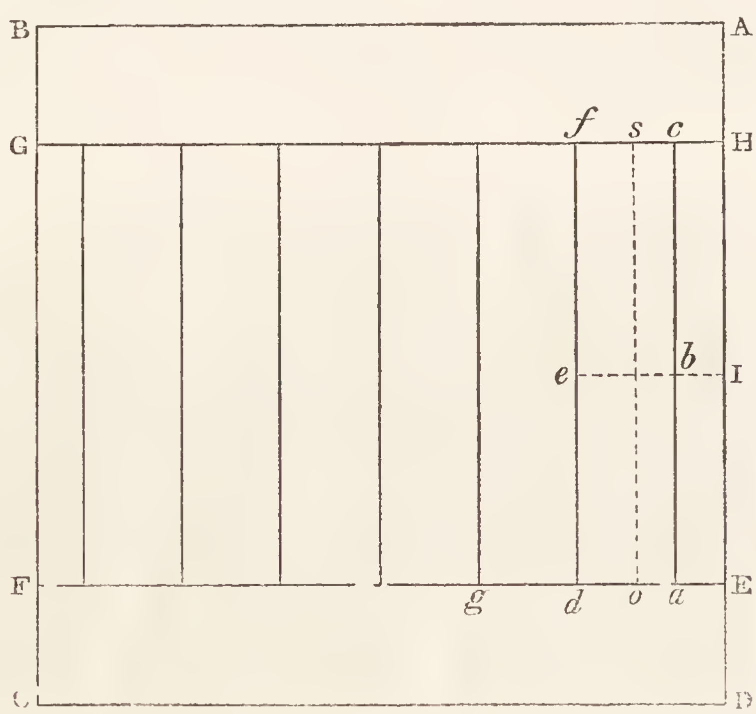
The field is now prepared for being ploughed into ridges, and the manner of doing so is this :—

The ploughman, beginning at the left hand side of the open furrow, ploughs his first furrow-slice towards it. He then, returning by the opposite side, performs the same operation, causing the two first furrow-slices to rest upon one another.

Thus, in forming his first ridge, he begins at the side of *a*, and, ploughing in the direction from *a* to *c*, he turns his first furrow-slice into the open furrow *a c*. When he arrives at *c* he turns his plough right about, and returning from *c* to *a*, he lays his second furrow-slice upon the first one, as at C, Fig. 95.

In this manner, by continuing always turning to the right-hand side, and laying his furrow-slices towards the centre of the ridge, until he has reached the boundary of the ridge EH, on the one side, and the line *o s* half-way between *c a*, and *d f*, on the other, he will have formed a ridge, of which *c a* is the crown or centre, and HE and *o s* the termination. By proceeding in this manner throughout the field, the whole will be formed into ridges, of which the first marked furrows are the centres.

Fig. 93.



It has been said that the ploughman continues turning his horses to the right, and that thus, after having proceeded from *a* to *c*, he returns from *c* to *a*, and so on, always ploughing round *a c*,

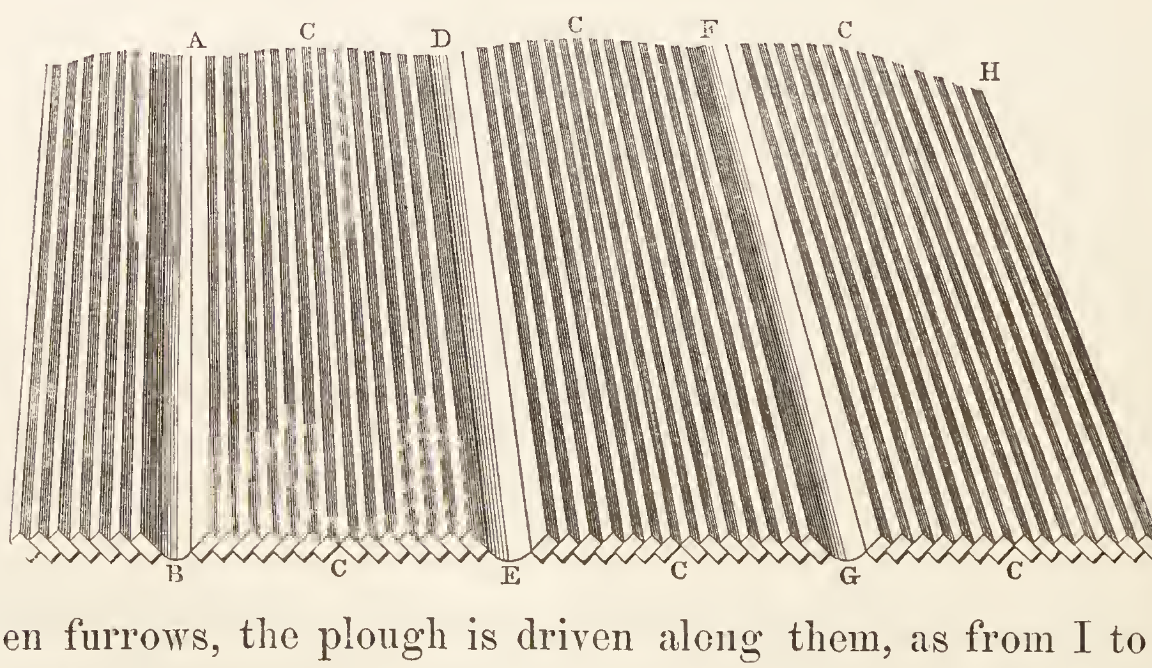
as a central line. When, however, he has proceeded from *a* to *c*, he may turn his horses left about, and return from *f* to *d*, and so on, always laying his furrow-slices towards *a c* and *f d* respectively. In this manner he will have ploughed the half of two adjoining ridges, and terminated at the space *o s* half-way between them. This method of ploughing, it will appear, has the same effect as turning the horses right about, and is the most frequent and convenient in practice.

In order to perform it in an accurate manner, the first operation after striking the furrows should be to plough together the two first furrow-slices of each centre. This being done, the workman proceeds to plough, each his own pair of half-ridges, until the field is completed. The first half-ridge HE *c a*, may be ploughed by all the ploughs following in the same direction, so as to turn the furrow-slices towards *c a*.

In the following figure, in which CC, CC, CC, are the centres of the ridges, the manner in which the successive furrow-slices have been laid upon one another is shewn.

By this laying of the earth towards the centres, the ridges acquire a certain elevation. By ploughing the earth away from the intervals AB, DE, FG, HI, the ground is hollowed at these parts, which now form the open or water furrows. To complete these

Fig. 94.



open furrows, the plough is driven along them, as from I to H, and then from H to I, so as to deepen them, and throw some earth up on each side. It is by these open tracks that the water

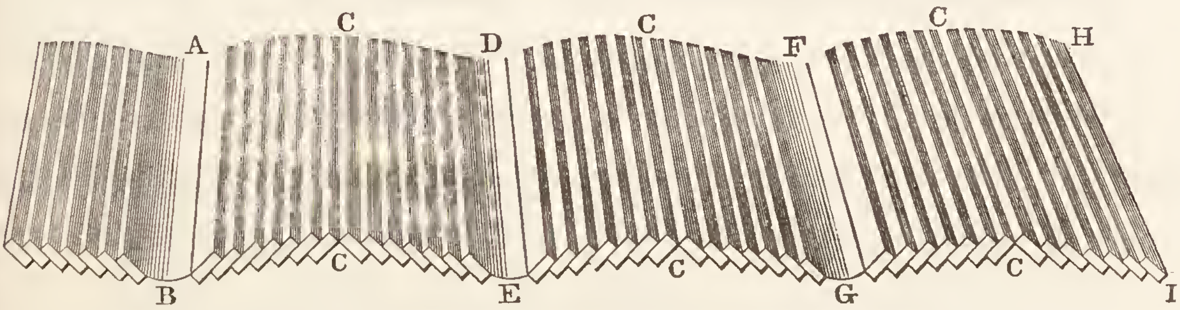
which falls upon the urface finds a passage; and they are termed water-furrows.

A certain, though not a great degree of elevation, is given to the ridge by this ploughing. It is frequently, however, necessary to give it a yet greater degree of curvature and elevation. This is done by ploughing the whole ridge a second time, and in a similar manner.

The plough is first driven along the centre of the ridge from C to C and then back again, forming an open furrow, as in the first striking of the furrows. Successive furrow-slices are then laid towards this furrow, in the same manner as in the previous ploughing. This is done with the successive furrow-slices, until the plough reaches the open furrows AB, DE, FG, HI. In this manner the whole ridge is ploughed, and an increased elevation and curvature given to it. This operation is termed *gathering*.

In performing the operation of gathering, it is important that the ridge be formed with a uniform curvature, so that it shall not have what is technically termed a shoulder and hollow part on each side of the crown. It is to prevent this defect that the open track is made along the crown before the first two slices are laid together; by which means the ploughman is better enabled to lay them upon each other, in such a manner that they shall not overlap and form a protuberance at the crown of the ridge. A transverse section of the ridges, when gathered, will appear thus:

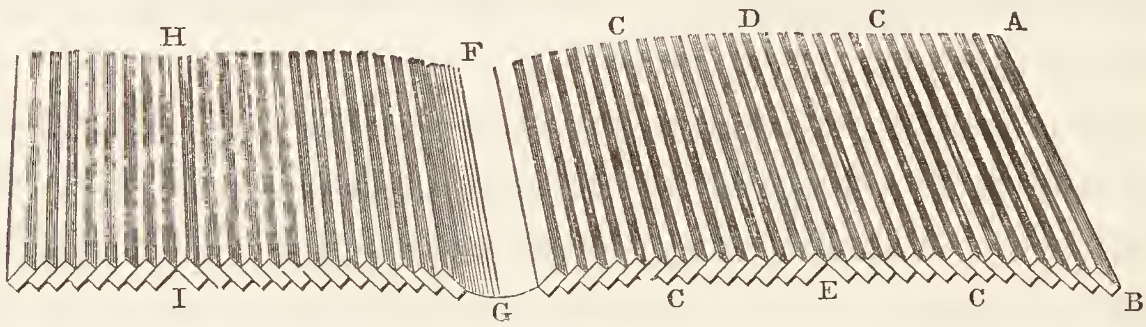
Fig. 95.



A ridge, however, being already formed, it may be wished to plough it again, and yet to preserve it at the same curvature and elevation. In this case, the plough is to enter at the open furrow, and to lay the successive furrow-slices towards it, until two adjoining ridges are ploughed. By this means all the slices of

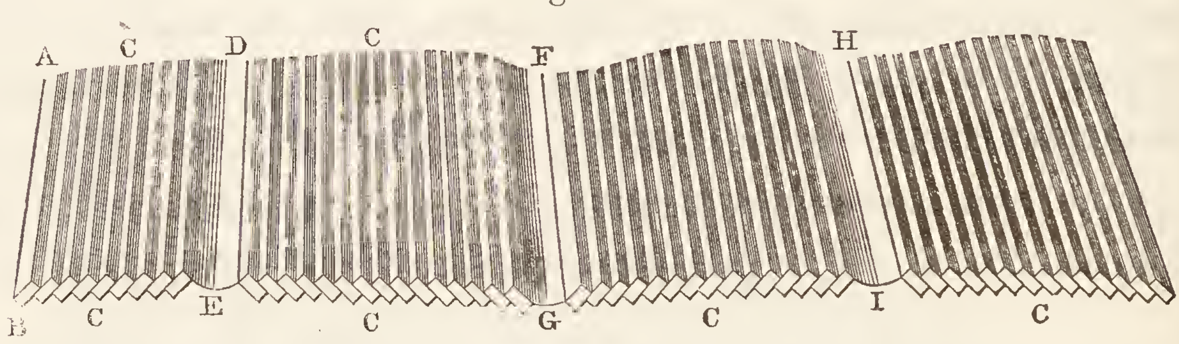
the same ridge lie in the same direction, and the curvature and elevation of the whole remain as before. This operation is termed *casting*, and the manner in which the furrow-slices rest upon one another will appear in the following figure.

Fig. 96.



In the operation of casting, two methods may be pursued. The two first furrow-slices, as those at E and I, may be laid resting upon each other, as in the figure above, in which case the two ridges will be formed as it were into one large ridge ; or else the open furrows at E and I may be preserved by keeping the two first furrow-slices at a little distance from each other, and preserving and clearing out the space between them, thus :

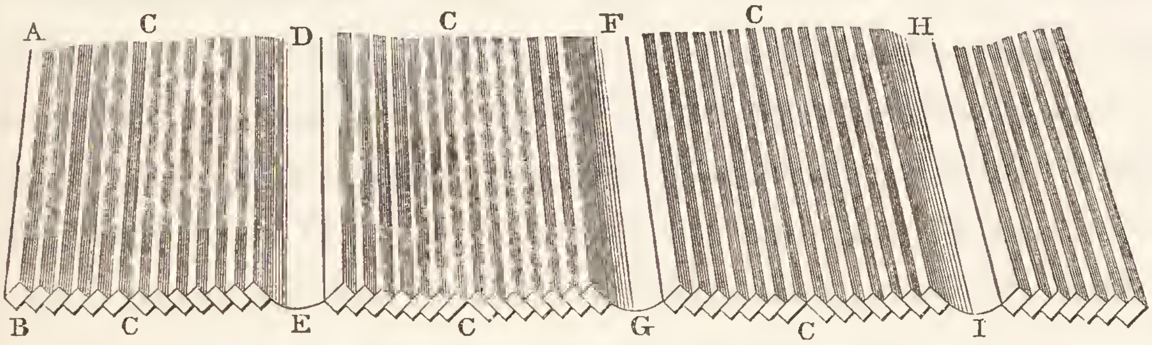
Fig. 97.



When land is ploughed in this manner, the ground is taken from one side of each two adjoining ridges at G, and laid towards the other, E and I, that is, it is gathered towards one side, and gathered from the other. In this manner the ground at the open furrow G, from which we gather, becomes more bare of earth than the open furrows E and I, towards which we gather. This is an imperfection unavoidable in casting a gathered ridge. When, therefore, we wish to cast a ridge twice in succession, we reverse the former mode of ploughing ; we gather towards the open furrow G, and from the open furrows E and I, and thus the ridge is restored to its former state.

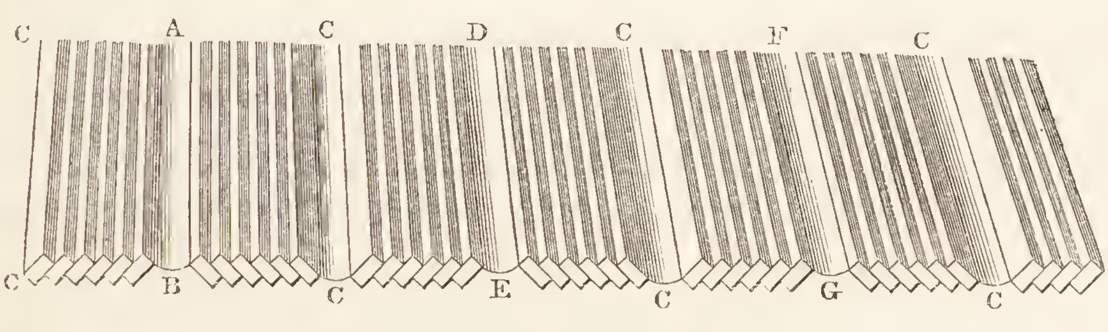
Another method of ploughing is *cleaving.* In this case, the plough commences at the open furrow, lays the first slice towards it, and then returning by the other side of the open furrow, lays the second slice upon the first, as in the following figure. When it has reached the centre, it stops, and begins with another pair of ridges, and ploughs the half of each pair together in the same manner. In this way the open furrows of the ridges become the centres, and the former centres become the open furrows. The operation of cleaving is of constant occurrence in the summer-fallow and other cleaning processes of tillage. When we wish to level a ridge we cleave it.

Fig. 98.



There are two variations to be noted in the practice of cleaving. Either the two first slices are laid close together, in which case the open furrows of the former ridges become the centres, and the former centres the open furrows, in the manner shewn in the last figure; or a certain distance is kept between the two first slices, and so the open furrow is preserved. In this case, each ridge is split into two ridges, and the number of open or water furrows is doubled, thus :

Fig. 99.



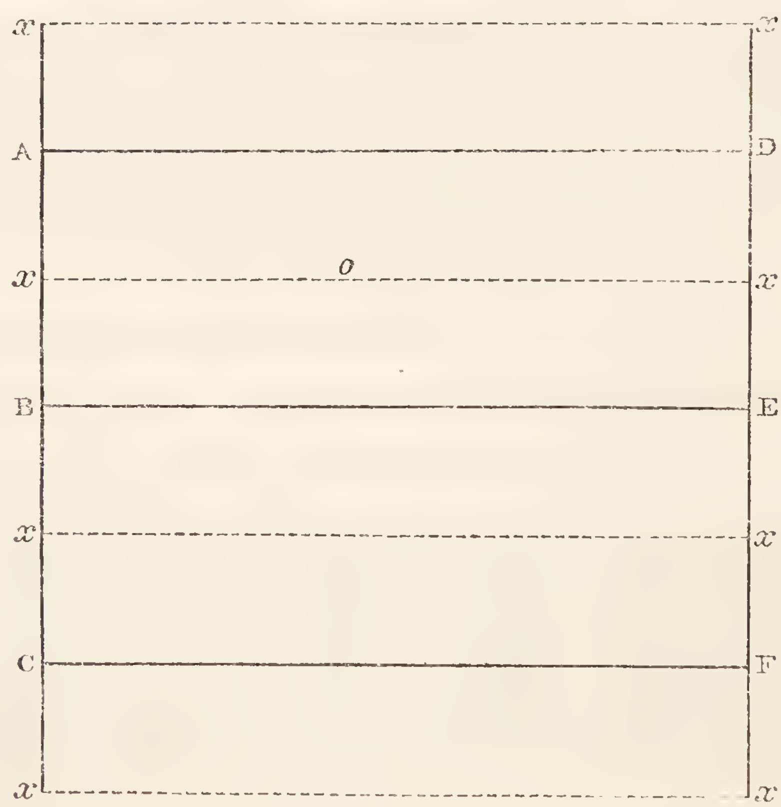
In the preceding figures, the furrow-slices are represented as being all of equal size; but in practice, the furrow-slices are

made somewhat shallower next the open furrows, and thus the ridges are more neatly rounded, and the interval of the water-furrows is smaller than the diagrams represent.

The next method of ploughing is *cross-ploughing*. This, as the name denotes, is ploughing in a direction crossing that of the former ridges and furrows.

In cross-ploughing, the workmen place themselves at equal distances from one another, as thirty yards, at the side of the field at which they are to begin to plough. Each then runs a straight furrow across the field, as from A to D, from B to E, from C to F. Each then returns as from D to A, from E to B, from F to C, laying always the successive furrow-slices towards the right hand, until each man arrives at the termination of his allotted space *xx*, *xx*, *xx*, *xx*. There has been thus formed by each workman one great ridge, but so extended that it may be said to be without curvature. The ploughmen, we perceive, turn from left to right around the first furrows AD, BE, CF. But they may also turn from right to left. Thus, in going from B

Fig. 100.



to E, the ploughman lays his first furrow-slice to the right hand. When he arrives at E, he may turn his horses left about, and

proceed to D, and returning from D to A, lay his first furrow-slice to the right hand towards DA. Turning left about then at A, he proceeds in the direction BE, and so on, always turning left about until he has arrived at the middle space *o*, when the whole space between AD and BE will have been ploughed.

Sometimes, for convenience and the saving of distance, he may plough in the first place round the central line BE, by turning from left to right, and then plough the remainder of the interval by turning from right to left.

These are matters of detail somewhat difficult perhaps to be described clearly, but so simple in themselves that they need only be seen in the field to be thoroughly understood.

The first operations, then, we have seen, is striking the furrows previous to forming the ridges. This is done by laying off, by means of furrows, first the lines of the head-lands, and then the parallel lines corresponding to the future centres of the ridges to be formed.

The next operation is forming the ridges. This is done by beginning at the centre, and ploughing towards it till each ridge is formed.

When ridges are formed, they may be subsequently ploughed in different ways.

First, They may be gathered; in which case, beginning at the crown, the ridge is ploughed, and an increased elevation given to it.

Secondly, They may be cast; in which case two ridges are ploughed together, and either formed into one large ridge, or, by keeping the water-furrows clear, retained in two ridges.

Thirdly, They may be cloven; in which case, beginning at the water-furrows, the half of each adjoining ridge is laid together. The first two furrow-slices may either be laid close together, or the water-furrow may be kept clear between them. In the first case, each ridge will have been so cloven as that the water-furrow shall have become the crown, and the crown the water-furrow. In the second case, each ridge will have been cloven into two, and the number of ridges and water-furrows doubled.

In the original laying out of ridges, the lines have been described as running straight through the field ; but it is frequently expedient, on account of the inequalities of the surface or other cause, to change the direction of the ridges at some part of the field so as to facilitate the discharge of water.

The application to this case of the principle of striking the furrow is easy. The ploughman makes a furrow where the change of direction is to take place, straight or curved, as circumstances may require. The one set of ridges terminate at this part, and the other are laid off from it in the new direction to be given. The ploughman, by means of his poles, as before, strikes this first set of furrows, terminating them at the furrow where the change of direction is to take place. From this furrow he strikes his second set of furrows in the direction in which they are to run. The part where the opposite set of furrows meet may be made an open furrow, or better, a raised-up ridge or head-land, with its water-furrows.

The direction of ridges must generally be regulated by the sloping of the fields, and the lying of ditches and fences, so that they may promote the main purpose for which they are formed, the carrying off of surface water. But, other circumstances being alike, they should be made to lie as much as possible north and south, and as rarely as possible east and west; for, in the latter case, when the ridges are much elevated, the north side has a somewhat less favourable exposure than the south side.

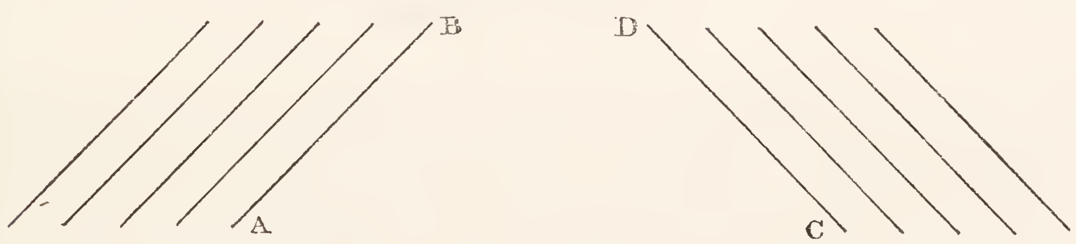
Ridges may be dispensed with, either when the land is naturally dry, or when it has been so thoroughly drained that the water finds a ready egress by the underground channels formed for it. In this case, all the operations of ploughing become more simple. The land is treated as in cross-ploughing, namely, by ploughing in divisions so large, that no sensible curvature is given to the surface; or sometimes by the ploughs following one another round the entire field, and terminating at the centre. When the ploughing is performed in this manner, there are no water-furrows to regulate the several operations of sowing, reaping, spreading of dung, &c.; and hence simple parallel ruts should be formed by

the plough along the field at equal distances, as 16, 18, or 20 feet. This system is capable of being reduced to practice in many cases; but requires to be adopted with great caution in a country so moist as this, and especially on all soils approaching to the stiffer clays.

In ploughing very steep land, it is frequently laid in ridges diagonally across the slope, for the purpose of rendering the labour more easy, and of lessening the danger of torrents carrying away the surface.

The precaution to be observed in this case, is to make the ridges slope upwards from the right hand, as from A to B in the following figure, and not to the left, as from C to D. For, in the first case, when the labouring cattle are ascending the steep, the plough is throwing the furrow-slice downhill; whereas, in the other case, when the cattle are ascending, they are raising the furrow-slice up-hill, by which their labour is greatly increased.

Fig. 101.



Besides the water-furrows of the ridges, which act as channels for carrying off the water, it is necessary, where there are hollow places in which water may stagnate, to form open furrows or channels. This is done by drawing an open furrow with the plough in the direction most convenient for the purpose. A workman then follows with a spade or shovel, and carefully opens all intersections with other furrows, so that there may be a free communication between them.

Sometimes it is necessary that the furrow made by the plough be further deepened by the spade, so as to form a channel sufficiently large; and wherever head-lands intercept the run of water, channels must be cut through them to the ditch or outlet, so that none may stagnate upon the ground. Attention to these details in practice is essential in all cases of tillage; and it manifests a

want of all skill and industrious habits in a farmer to suffer his lands to be injured by the stagnating upon it of surface-water.

The quantity of land which a plough can go over in an ordinary day's work will, when the instruments are equally good, chiefly depend upon the nature of the soil, and the manner of ploughing.

The common calculation, where good ploughing is practised, is, that a pair of horses will plough an acre when in grass in nine hours. In very stiff soils, less will be done; and in very light soils, more. When land is in a loose and pulverized state, from a third to a half more may be done in the time mentioned. In winter, when six hours are generally regarded as a day's work, and at which time the soil is wet, about half an acre in the day may be considered as ordinary work. But taking the year throughout, and soils in all their different states, it may be held that an acre in the day can be done by a man and a pair of horses.*

2. Harrowing.

The next of the simple operations of tillage to be considered is that of harrowing. One man or boy drives a pair of horses and a pair of harrows, though sometimes one person drives three horses and three harrows. The driver walks behind with long reins, which enable him to guide and urge forward the horses; and he must be ready to lift up, with his hand or a crooked stick which he holds for the purpose, the harrows when they are impeded by roots, weeds, or other substances. By lifting up the harrow when in motion, the weeds collected by the teeth fall down.

The harrows pass over the ridge either longitudinally or across. At the end of the ridge they are turned, and generally pass again over the same ground. This is called a double turn of the harrows. When they do not return over the same ground, but pass to another space, they are said to give a single turn. Sometimes

* In some of the very stiff clays of England, as, for example, the London Clay-formation, this calculation will not hold, because the farmers may be often obliged to employ four horses in a team.

a single turn suffices for particular purposes, but more frequently a double turn is required.

Sometimes the harrows give two or more double turns in the same direction, but more generally, after one double turn they give the next double turn across the direction of the previous one, and so on lengthwise and across alternately.

When land is to be pulverized and cleaned of root-weeds, in the manner to be afterwards explained, the operation consists of repeated double turns of the harrows in different directions. The root-weeds being dragged to the surface, they are collected by the hand, and carried off the ground or burned. The plough prepares the ground for the action of the harrow, and the plough and the harrow acting by turns, the land is ultimately pulverized and cleaned.

Besides the cleaning of the ground, a purpose in harrowing is to cover the seeds of the cultivated plants.

The number of harrowings to be given for this end depends upon the state of the ground and other circumstances. When the surface is matted together by the roots of plants, as in the case of land ploughed when in grass, repeated double turns are required to cover the seeds in a proper manner. But when land is already well pulverized, as in the case of summer-fallow, a smaller degree of labour is required. Sometimes two double turns are given, sometimes one, and in some cases, as those when the smaller seeds of grasses are sown, a single turn will suffice.

The operation of harrowing is best performed when the land is dry. Harrowing when the land is wet, is as much as possible to be avoided, both on account of the less efficiency of the operation, and of the injury done to the ground by the treading of the working cattle.

In the case of covering seeds, however, in unfavourable seasons, it is often necessary to harrow the ground when in a wet state. This is one of the accidents which embarrass the farmer, and call for the exercise of his practical knowledge. In extreme cases of this kind, the practice has been sometimes resorted to of attaching several harrows to a beam stretching across the ridge, in the

manner before represented (Fig. 23), and of causing the animals of draught to walk in the open furrows.

Harrowing is not a very severe labour for the working-cattle, though more so than from the small weight of the instrument might be inferred. It is the starting and irregular motion of the harrow, and the sinking of the animal's feet in the soft ground, that form the principal labour in drawing. From this latter cause, a light poney or a colt will do more work in proportion to his strength than a heavier horse.

The space of ground that can be passed over by a pair of horses in a summer day's work is generally held to be about twelve acres, so that a pair of harrows will give a double turn to six acres in a day; hence, as a plough will work one acre in a day, the expense of giving a double turn of the harrows is equal to one-sixth part of the expense of giving one ploughing.

3. Action of the Grubber.

The grubber is subsidiary to the plough, and similar in its mode of action to the harrow.

When our purpose is to stir the ground without turning it over, the grubber may supersede the operation of the plough. It is more frequently used, however, as a substitute for the harrow in the cleaning of land; and it excels the harrow in this, that, having a heavier frame, and being fixed on wheels, it has not the starting and irregular motion of the harrow, and is not subject to be thrown out of the ground, when encountered by obstacles.

In using the grubber, the workman walks behind, and when handles are employed, he makes use of them to lift the teeth or coulters out of the ground, in turning at the end of the ridges, or when otherwise necessary.

Generally the grubber passes once over the ground to be tilled, but it is frequently found expedient to go twice over the ground. In this case, it is proper to set the teeth at half the depth required in the first operation, and in the second to set them at the

full depth, and in working the second time to cross at right angles to the direction of the first operation.

The grubber, with two horses, will go over about six acres a-day, so that the expense of one operation is equal to one-sixth of that of the plough, or equal to a double turn of the harrows.

4. Rolling.

The roller is employed upon the farm in two distinct operations. It is used to assist the harrow in the cleaning of ground, or to smooth and consolidate the surface of land in grass or crop.

When employed to clean land in conjunction with the harrow, the latter is first used, by which the clods, or indurated masses of the soil, are brought to the surface. The roller is then brought to act upon these indurated masses, which it bruises by its weight; and thus it performs, though in a different manner, the same operation of pulverizing the earth which the harrow does. By this mean the harrow is enabled to act upon those clods upon which its teeth could not otherwise make an impression.

The further use of the roller is the smoothing and compressing of the surface of the ground; and sometimes, in performing this operation, it serves to cover certain seeds, as will be afterwards explained.

In using the roller, when the land is in ridges, it is to be driven across the ridges, and not longitudinally.

Sometimes one horse is employed in the operation of rolling, but more frequently two. In this case, they are generally yoked one in the shafts, and one before, though they could exert a greater force in pulling, were they to be yoked abreast. But this is not of any essential importance, two horses yoked in this manner being able to move the heaviest rollers which are employed.

The quantity of land which a roller with a cylinder of five feet can go over in a day is about five acres. By extending the length of the cylinder, a greater quantity of work will be done in appearance, though not in reality.

5. Digging.

The plough, the harrow, and the roller, are the essential implements of preparatory tillage. To these, however, and the grubber, may be added the spade; which, though properly the instrument of culture in the garden, may be employed occasionally in the fields.

The cases in which the spade may be used in field culture are those where, from particular causes, the plough cannot be used.

Such is sometimes the case in the first improvement of very steep or rocky ground, where the plough cannot act, or in the case of deep peat, when it is so soft as not to bear the weight of the working cattle.

The tillage by the spade may either be simple digging, to the depth of one spit, or trenching to the depth of more than one spit. In the case of trenching, the usual purpose is to deepen the soil, by laying the surface stratum underneath, and bringing a portion of the subsoil to the day. This is best done by digging a trench and wheeling away the earth ; and then digging another trench along the side of the first one, throwing the soil first, and then the subsoil, into the first trench. In this manner, the space to be digged is gone over with successive trenches ; and when the whole space is passed over, the earth which had been wheeled away is used to fill the last formed trench.

Cultivation by the spade, however, though more efficient, is greatly more expensive than by the plough, at least when two-horse ploughs are in use. It may be sometimes employed with advantage, though rarely on the great scale, where the profit depends upon economy of labour.

The further simple operations of tillage are those performed by the sowing and hoeing machines, and by other instruments of the farm. The manner of using these will be from time to time referred to ; but it is by practice and observation that the full knowledge is to be obtained. The first object of study of the

learner should be the general form of the machines, and the particular purposes for which they are intended. This knowledge being obtained, there is only wanted the opportunity of seeing them employed in the field to understand the manner of using them.

V. PREPARATION OF LAND FOR CROPS.

1. Fallowing.

The fallowing of land consists of a course of tillage continued for a certain time. When it is continued for an entire season, the process is termed the Summer-fallow.

A course of tillage during only a part of the season is adopted in the case of preparing land for such crops as the turnip, the cabbage, the potato, which are thence frequently termed *fallow-crops.* This preparation consists of a series of ploughings, harrowings, and other operations, continued until the land is cleaned, and otherwise fitted for the crop to be cultivated.

The extension of the culture of fallow-crops has greatly lessened the necessity of the summer-fallow; for the ground receiving a good preparation for this class of crops, and they, from the wide intervals at which they are cultivated, admitting of an efficient tillage during their growth, the farmer is more enabled to dispense with the necessity of devoting an entire year to the tillage of his land.

It is chiefly on the stiffer clays that the summer-fallow may be held to be an essential branch of farm management in this country. These are tilled with greater difficulty than the lighter soils, and do not always admit of the cultivation of those particular classes of plants, as the turnip, which are suited to the lighter soils, and which render upon them an entire summer-fallow unnecessary. A further reason exists for the adoption of

the summer-fallow on the stiffer clays, namely, that the most valuable of their productions is wheat, for which the summer-fallow affords the best preparation. The manner of performing this process, therefore, merits the serious attention of farmers in this country.

Whatever be the nature of the soil to be fallowed, the first ploughing is in all cases to be given in autumn, or before winter, so that the soil may receive the influence of the winter-frosts, and the growth of weeds be checked; for certain weeds will grow during the months of autumn, and partially in winter and in early spring; but by inverting the surface, and exposing the roots of those plants, and the under part of the sod, to the frost, the vegetation is checked until the process of ploughing can be resumed in the following spring.

In all cases the first ploughing should be as deep as the plough can conveniently be made to go. A good plough with a pair of horses can easily plough from eight to nine inches deep, and this is in most cases an efficient tillage. But, should the nature of the soil render it necessary, an additional force of draught must be employed, so that the requisite depth of furrow may be given. Thus, in some of the marly and tenacious soils of England, four horses may be required to give sufficient depth to the first ploughing of fallow. Three horses may be also used; these, with a good plough, forming an efficient team, which may be managed by one ploughman.

With respect to the manner of laying the ridges, that kind of ploughing must be adopted which is calculated to keep the land dry during the months of winter, this being an essential point of practice in the class of soils for which the summer-fallow is required.

A good method of preserving the land in a dry state is cleaving with open furrows (see Fig. 99). In this manner each ridge is divided into two, so that good provision is made for allowing the free egress of water.

Sometimes the ridges may be gathered (Fig. 95), and at other times, when the land is moderately dry, they may be cast (Fig. 96).

In whatever manner the ridges are ploughed they remain in the same state till the following spring, and care therefore must be taken that all the necessary cross-furrows and channels shall be made and carefully cleaned out, so that no water may stagnate upon the field.

In the ordinary management of the farm, the first operation in spring, as soon as the weather allows, is the sowing of the spring-crops of corn. When this essential labour of the season is completed, which in this country is generally from the middle to the end of April, the tillage of the land intended for such crops as the turnip, the potato, and other fallow-crops is to be resumed. But though these are the first in the order of preparation, and must necessarily be first attended to, yet the summer-fallow should not be neglected at this early season, but should receive one ploughing not later than the month of May, and the earlier in the month the better.

Now this, the second ploughing of the summer-fallow, may be made in two ways. The land may be either cross-ploughed, or ploughed in the direction of the former ridges. On the lighter and drier soils, in the cases where such soils are subjected to the summer-fallow, the cross-ploughing is the better method. But, in the case of the stiffer clays, the ploughing in the direction of the former ridges is to be preferred; for this is a provision against the effects of heavy falls of rain, which, were they to occur at this early season, when the land was ploughed, without open furrows to carry off the water, might so saturate it as to render the subsequent tillage precarious and difficult.

The next ploughing, which is to be as early in June as the other labours of the farm will allow, is to be made across. Immediately after this ploughing, the land is to be harrowed by repeated double turns, the direction of each double turn crossing that of the previous one. These double turns are to be repeated four, five, or more times, as occasion may require; and the roots of all plants which are dragged to the surface by the harrows are to be carefully collected by the hand and laid in heaps. A cart then passing along the rows of heaps, the collected plants

are to be forked or thrown into it, and carried off the ground. They may be formed into a compost by being mixed with quicklime, so as to destroy their vegetative powers, and employed in the manner described under the head, Manures.

Sometimes these weeds are burned on the ground, and their ashes spread upon the surface; but this practice is not to be imitated, the ashes yielding an inconsiderable quantity of manure as compared with that which is produced by forming the weeds into a compost.

It is of great importance at this period of the summer-fallow, to drag to the surface and collect as large a portion as possible of the roots of vivacious weeds in the ground; for, this being the period of active vegetation, every part of these roots which is left in the ground will grow again and extend itself.

It is by the repeated action of the harrows that these roots are detached from the soil and dragged to the surface. When necessary, the roller is also to be employed. This, bruising the clods or indurated masses of earth upon the surface, enables the teeth of the harrow to act upon them. When the roller passes over the ground, the harrows immediately follow.

At this time, too, the grubber may be employed, as subsidiary to the action of the harrow.

This is a period of the summer-fallow at which all obstructions arising from land-fast stones and other impediments to tillage are to be removed; and if drains are required, it is now convenient to form them, the stones collected upon the surface being carried forward at once to the drains, and filled into them in the manner to be afterwards explained.

This, indeed, is merely a matter of convenience when the stones are in readiness, for the time of summer-fallow is not really the best for the forming of drains, owing to the hazard of heavy rains occurring, and carrying the soil, which is then loose, into the drains. This, however, is but a contingency, and there is convenience in forming such drains as may be needed at this time: and not only at this time, but during all the subsequent operations of the summer-fallow, draining, the removing of obstruc-

tions to tillage, and other works, are carried on. The obstructions of this kind to be removed are, generally speaking, anything that may impede the path of the plough, and interrupt the common operations of tillage,—such are the roots of trees, stones, inequalities of the surface, and the like.

It has been seen, then, that, in the management of the summer-fallow, the first ploughing is to be given before winter, when the land is ploughed lengthwise, in such a manner as that the land shall be kept dry until the tillage can be resumed in the following spring; that the second ploughing is to be given as early as possible in May, and, in the case of stiff soils, lengthwise; and that the third ploughing, which, in the common course of farm labour, we may hope to accomplish in June, is to be given across, when the principal labour of harrowing, rolling, and disengaging weeds, is performed, and when opportunity is taken to begin to drain, clear the ground of stones, and perform similar operations required.

As soon after the last ploughing and cleaning, as the state of the weather and the labours of the farm will allow, the fourth ploughing is to be given. This ploughing may be performed in two ways. It may either be given lengthwise, and the land formed into ridges, or the whole may be ploughed in large divisions, without regarding ridges, as in cross-ploughing.

The former method may be adopted when the season is critical, and the land stiff and naturally wet. This is in order to avoid further hazards from great falls of rain; for, by forming the land into ridges, it is placed in a state of comparative security. But it allows of a better subsequent tillage of the land to lay it flat, by ploughing it in large divisions without yet forming it into ridges.

In this case, the land may be ploughed in a direction at right angles to the previous ploughing, that is, in the direction in which the future ridges are to run; but it will be better to plough somewhat diagonally, that is, nearly in the direction from corner to corner of the field. This is done in order that two successive ploughings may not be in one direction, for the next ploughing

to be given, as we shall immediately see, must necessarily be lengthwise in the direction of the ridges. But, by deviating from this direction with the ploughing now to be given, the two successive ploughings will cross one another, and thus the tilling will be better performed.

No sooner is this diagonal ploughing completed, than the process of harrowing, rolling, and cleaning the ground of the roots of vivacious weeds, is to be renewed, precisely as after the preceding ploughing. It is not necessary or expedient that the process of harrowing shall be carried further than is absolutely required to disengage the weeds; but to this extent it is important that it be carried, so that the land may now be cleaned.

These two ploughings, with their corresponding harrowings, are of the utmost importance in the management of the summer-fallow. If the weather has been favourable, the land may now be expected to be effectually cleaned, and thus far to be in good order. Sometimes a further ploughing may be required for the purpose of completing the cleaning process, but whether this be so or not, the land ought now to be formed into ridges. This is necessary, in order to provide against the contingency of heavy rains, which, were they to occur at this period, when the land is lying in a flat state, might so soak it as greatly to retard the future labours.

We now, therefore, proceed to strike the furrows in the manner formerly explained. The land is then ploughed and formed into ridges, and this completes the fifth ploughing which it has received. The land will generally be now ready to have the dung laid upon it. But in some cases it may require a sixth ploughing before it is sufficiently cleaned and prepared for the dung. In this case, the land being harrowed, and the remaining weeds collected as formerly, it is ploughed again in the line of the ridges.

We may proceed, however, upon the supposition, that this further ploughing and cleaning are not required, and that the land, after the fifth ploughing, is ready for the application of the dung. This may bring us, in the ordinary course of farm-labour, to the month of August.

Now, the dung, according to the practice before described, has been previously carried out and laid in large heaps in the field, where it has undergone a certain degree of fermentation. Should this not have taken place sufficiently, the heaps must be turned, so that the dung may be brought to a fit state for use.

The dung is now conveyed to the land in carts from the heaps, the carts being driven along the ridges. It is dragged out from behind by the workman with the dung-drag (Fig. 80) into heaps, as nearly as possible of equal size, and at equal distances, in rows along each ridge. Sometimes, to insure accuracy, the ridges are divided, by furrows run across them, into rectangular spaces, each space receiving its allotted quantity of dung. But in general the eye and practical knowledge of the workman will enable him to drag out and deposit the heaps in the quantity, and with the accuracy that may be required.

Several persons, who may be females or young lads, then spread out the dung all across the ridge, by means of light three-pronged forks (Fig. 73). This operation should be performed with much attention, so that the dung may be spread regularly over the ridge.

Close upon the work of the spreaders, the ploughs are to follow and cover the dung. This is done by gathering the ridge, so that, while the ploughing covers the dung, the elevation of the ridge is increased.

The dung being covered in this manner, and the ridge raised, the land is to remain untouched for a few weeks, so that the dung may be decomposed and incorporated with the soil. When the dung has been previously fermented in a proper manner, this incorporation will be completed in a very short time.

The land is now ready to receive what is called the seed-furrow, which is the ploughing given to it previous to the seeds being sown. In this ploughing the ridge is again gathered, but the ploughing being very shallow, it has little effect in raising the ridge higher.

After this final ploughing, and upon the surface now exposed, the seeds, usually of wheat, are to be sown in the manner to be

afterwards described. This generally takes place about the middle of September or later, and completes the important operations of the summer-fallow and sowing of the wheat-seeds.

In this detail, the manner of applying the dung has been described; but there is likewise to be considered the manner of applying lime, when this substance is to be laid upon the land in summer-fallow.

There are two periods at which the lime may be applied,—either before the dung is laid on, or afterwards. In the former case, the lime may be laid on just after the land has been formed into ridges, and when it is ready to receive the dung.

The quick-lime, as it is brought from the kilns, may be laid down in heaps of about five carts or more each, at regular distances, upon the head-lands, or where convenient. In this case, it is brought to the farm as opportunity offers, and slacked slowly and regularly.

When we are prepared to spread it upon the ground, a person with a broad-pointed shovel (Fig. 62) is appointed to each heap. He fills his cart, drives it along the ridge, and spreads the lime abroad upon the surface, taking it out with his broad-pointed shovel from the cart behind: two carts and two men may be appointed for each heap, the one man filling the cart at the heap, and the other spreading the lime upon the ridge.

Both men and horses sometimes experience injury from the caustic effects of the lime, especially when the weather is moist. The face of the man may be defended by a thin handkerchief, and the back of the horse should be covered.

When the lime is spread, the land must be immediately harrowed, to incorporate the lime with the soil. This being done, the dung is to be spread upon the ground, and covered by the plough, in the manner before described.

But frequently the dung is first spread, and the lime is not laid on until just before giving the seed-furrow. This answers very well, provided the land has lain a sufficient time after the dung has been spread, so that the dung may be decomposed and mixed with the soil.

These details have an especial reference to the stiffer soils, which are those on which the summer-fallow is generally practised. When the lighter soils are to be fallowed, the process of cleaning is more easy, and there is less hazard of serious interruption from the state of the weather. The only variation with regard to the lighter soils that need be referred to, is in the first spring-ploughing. In the case of such soils, this ploughing may be given at once across, and the process of harrowing and cleaning then commenced. This is precisely the management pursued in the case of turnips and similar fallow-crops; so that, when the learner comprehends the operations of the summer-fallow thus far, he is acquainted with the manner of preparing the land for an extensive and important class of plants.

In the preceding detail, the ordinary operations of the summer-fallow have been described; but the nature of the seasons, the state of the land, the prevailing weeds to be eradicated, and other circumstances, produce variations in the course of management, which, however, it is not necessary here to point out. They are little subject to rule, but are best determined by the judgment of the farmer, as the cases themselves arise. A more important purpose is served to the student of agriculture, by pointing out to him the manner of managing the summer-fallow upon approved principles. Knowing this, a little experience will soon shew him how to adopt those variations of practice which the state of the season and other circumstances may render expedient.

The process of the summer-fallow, conducted as it should be, enables us to effect the tillage of clay-lands in a manner calculated to eradicate weeds, and fit the land for bearing a lengthened rotation of crops.

After a complete summer-fallow, the land is seen to be in the best order which circumstances will allow. It acquires that mellowness indicative of fertility, so familiar to the eye of the farmer, yet so difficult to be described. It is frequently observed by farmers, that clay-lands, in this climate, get into an adhesive, and, as it is termed, a sour state, by the long repetition of crops. The giving them from time to time the mellowing influence of a sum-

mer-fallow, during which weeds may be extirpated, and the manures applied in the most beneficial manner, is found to have the best effects in restoring the fertility of the soil, and fitting it to yield an increased produce in succeeding years. One advantage, too, of the summer-fallow, not to be disregarded, is, that it divides the labour of tilling a farm more equally throughout the year.

2. Levelling Ground, and Removing Obstructions to Tillage.

Various impediments may exist to the free action of the plough, and the other operations of tillage, which it is the province of the cultivator to lessen or remove. The most common of these impediments are stones, the roots of trees and shrubby plants, inequalities of the surface, and swamps or morasses.

Stones are either loose, and capable of being removed by the hand, or they are large, and firmly fixed in the ground.

The loose stones which are mixed with the soil, are either found upon the surface, or they are turned up by the action of the tilling instruments. They may be removed at various periods. The most convenient is the time of summer-fallow, or when preparing the ground for fallow-crops. A cart passing slowly along the ridge, the stones are picked up and thrown into it; and if there is a sufficient number of labourers, usually young persons, this method is sufficiently expeditious, and does not require that the stones shall be previously collected into heaps. The stones of this kind may be employed for draining, building the walls of fences, or other purposes.

Another period frequently taken for gathering loose stones from the surface, is when land, which had been sown in the previous year with the seeds of clover and grasses, is to be mown for hay. It may become, in this case, necessary to remove from the surface such loose stones as may impede the action of the scythe. This is done in spring, before the young plants have so grown as to cover the surface. A cart moving along the ridge,

the stones, collected by a sufficient number of young labourers, are at once thrown into it, and so removed; but sometimes, when the ground is too wet to allow a cart to go upon it, the stones are piled into little heaps in the water-furrows, and removed when the hay is mown.

But the cases of difficulty are, when large land-fast stones are found at or near the surface. These interrupt the labour of tillage, and frequently break the instruments which strike against them. The plough is often shattered by striking upon a concealed stone, whence results not only injury to the instrument, but the loss of time before it can be repaired, or its place supplied. It becomes then a matter of good practice, to remove from cultivated land such stones as may interrupt the operations of tillage.

If they cannot be lifted by manual labour into a cart, they may be previously broken. This may be frequently done by the strokes of a sledge; and when the stones are not of great size, this is the most common method employed. In other cases, gunpowder may be used to blast them, in the manner employed in quarries. There are certain kinds of stones which will break by the application of heat. Gneiss and some slaty rocks may frequently be broken by kindling upon them some straw or brushwood.

In these various cases, the fragments are to be removed, and employed in draining, building, or other purposes to which they may be suited.

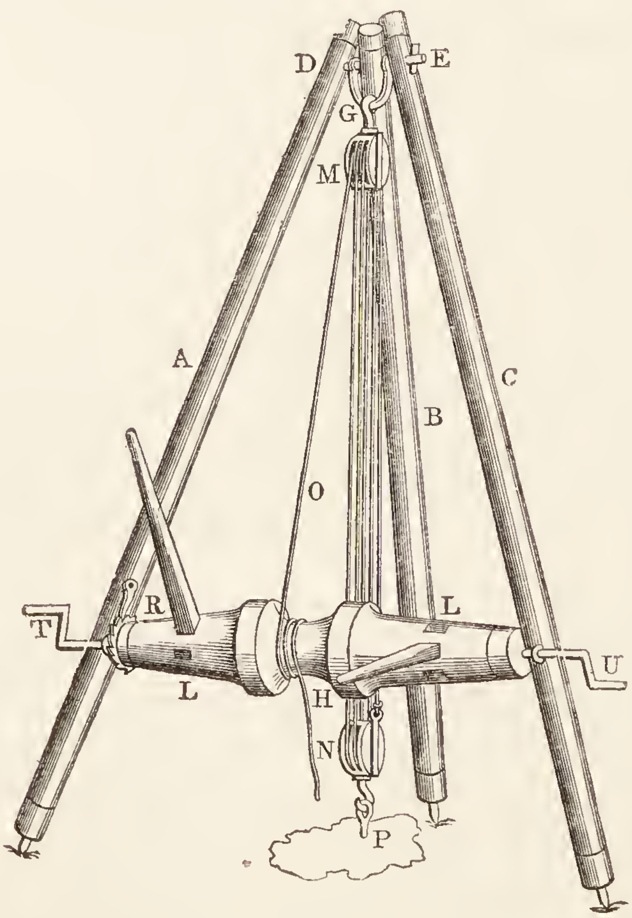
Sometimes farmers think it sufficient to place the stone beneath the reach of the plough, by digging a hole underneath it, into which it may fall. This, however, is itself attended with considerable labour, and the better practice, for the most part, is to break and remove the stone.

Methods have also been employed to lift up the stones entire, so that, being hoisted into a cart, or other carriage, they may be removed. One of these methods is by means of a very singular apparatus, formed in the following manner:—

A, B, and C, are three strong wooden posts, about 14 feet in length, through the ends of which are holes, for the reception of the strong iron-pin DE, upon which is made to slide the curved

iron-bar G. The holes through which the pin passes being of such a size as to allow a little play to the posts, these may be stretched out like the legs of the common theodolite, in the manner represented in the figure. To the curved iron-bar are then attached the fixed block M, and the moveable block N, containing the like number of pulleys. Each of these blocks must be hooped with a strong bar of iron, and the pulleys must be of a size sufficient to admit of a thick rope passing over them. To the lower block N is to be hooked the iron plug P, consisting of a ring for attaching it to the apparatus, of a flat part through which the ring passes, and of a cylindrical part. This cylindrical part may be 2 inches in length, $\frac{7}{8}$ of an inch in diameter at the point, and gradually increasing to about $\frac{1}{16}$ part of an inch more at the neck, where it joins the flat part. The rope O, passing over the fixed pulleys, is attached to the windlass, H, which is fixed to the posts A and C. At each end of this windlass is a winch, T and U, for the purpose of saving time in tightening

Fig. 102.



the ropes previous to the windlass being worked. To work the windlass, there are stout bars or levers, for the reception of which

are mortises at L, L, as shewn in the figure. At one end of the windlass is fixed a rachet-wheel with a catch R, fixed to the post A, for the purpose of preventing the weight from falling when the moving power is withdrawn. The posts A and C should be connected by a bar, to keep them steady in their place.

The machine thus formed is to be placed over the stone to be raised by extending the posts on each side of it, and then the windlass is to be attached. Of the stone to be thus raised, however large it be, it is enough that the smallest part can be seen. At this part let a workman, with a mallet and the common boring chisel of masons, make a circular hole, about 2 inches deep, and as perpendicular as possible, so that a stroke or two of the hammer may be necessary to drive the pin home. When thus driven an inch more or less into the stone, it is attached to the block, and the ropes are tightened by turning the winch. Nothing more is now necessary but to set the men to work the windlass with the levers ; and, with no other fastening than this simple pin, stones of some tons weight may be easily raised from the ground. Being raised up by the pulleys, the stone may be hoisted into a cart or other convenient carriage, and removed from the ground.*

The next class of obstructions to be referred to, are the roots of trees and shrubby plants.

In the newly-settled countries of America, the trees to be felled are usually cut several feet above the surface of the ground. This is most cheaply and quickly done by means of a strong hatchet, and practice renders those who are used to this kind of work extremely expert. The stumps and roots are then left to the slow progress of natural decay, the ground, in the mean time, being tilled. In this country, such a course would be unprofit-

* An account of this curious machine, the invention of Mr Richardson, Keswick, and an explanation of the principle on which the iron-pin is retained by the stone, though simply driven into it, were given by me in the Edinburgh Philosophical Journal. An account of it was subsequently published in the Transactions of the Highland Society of Scotland. The iron-pin, it was shewn, is retained in its place by the elasticity of the stone. It is only the harder kinds of stones that can be raised in this manner.

able, and it is always deemed expedient to grub up at once such roots of trees as interrupt the ordinary labours of tillage. This is done by clearing away the earth around the tree to the distance of a few feet, and cutting through the branches of the root at the outside of the cleared space. Sometimes the body of the root is wrenched up entire by means of levers, and sometimes it is split by wedges. When grubbing is carried on on the large scale, the instruments of the grubber are,—a spade and mattock, a dog-iron, as it is called, or bent iron-bar with a ring, through which a lever may be passed (Fig. 103), a strong lever and rope, a set of iron-wedges, a large wooden wedge, and a mallet. Workmen who have experience in grubbing become expert in the practice, and in districts where fuel is scarce, the roots will more than repay the wages of the workmen.

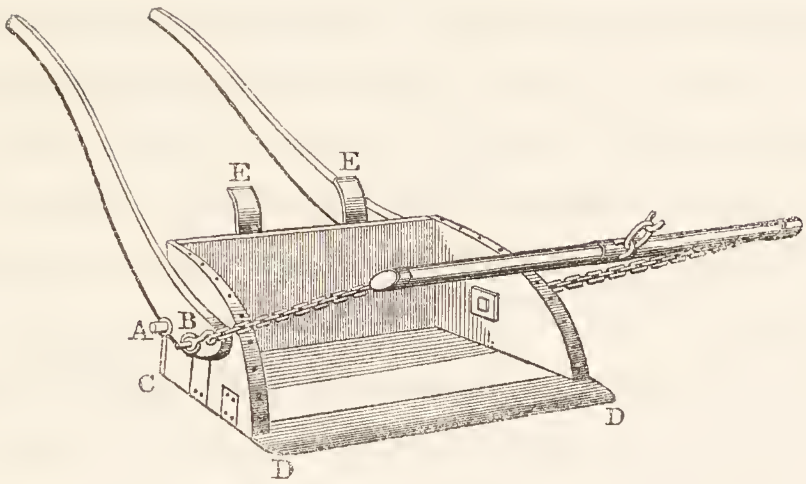
Fig. 103.

The other kinds of roots which may interrupt the labours of tillage, are those of such plants as the whin, the broom, and the bramble. The plants being hoed down close to the surface, the most economical means of getting rid of the roots, is by means of a powerful plough, having a spear-shaped share, and not a winged one, like that of the plough at common work. Trenching by manual labour is more efficient, but more expensive.

Another interruption to tillage arises from inequalities of the surface. In many cases of ordinary tillage, the plough will be sufficient to level inequalities. In this case, it acts by repeated cleaving of the ground to be levelled. Thus, where a hollow exists, by the repeated action of the plough on the sides, a sufficient quantity of earth may be thrown into the hollow to fill it up; and the surface-soil may have been previously removed by the spade, and, after the ground has been levelled, spread over the surface. Sometimes the spade alone is used to level ground, the earth being thrown or wheeled into the hollow to be filled.

In certain cases peculiar implements are employed to reduce inequalities. One of the best is represented in the following figure:—

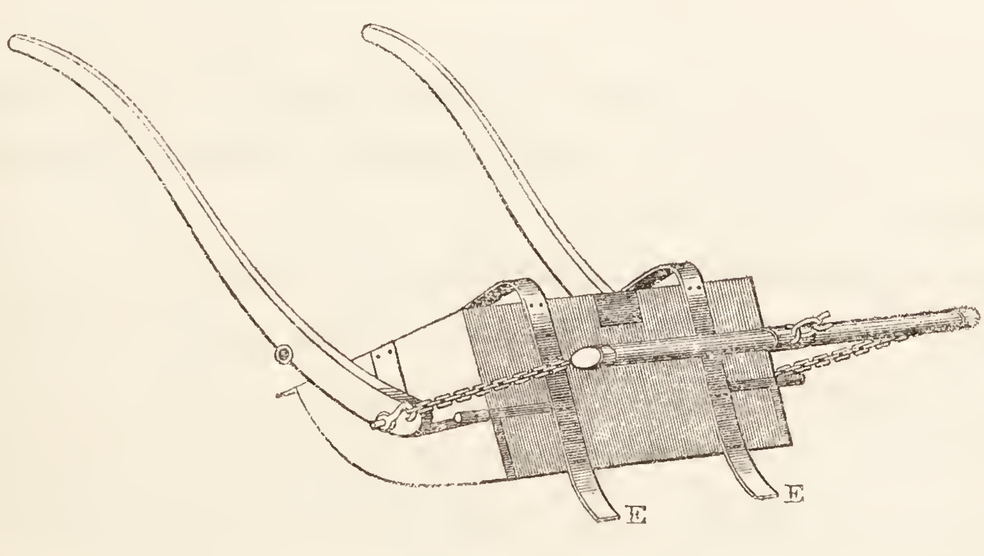
Fig. 104.



It consists of a box in the form of a large shovel, drawn by a pair of horses. There is a short iron-pin on each side fixed to the box, which passes through a hole or eye in the handle at A. When the handles and pin are in this position, the box is fixed in its place. But by disengaging the handles from the pins, which is done by merely stretching them out a little on each side, the box can turn round upon B as an axle.

The manner of using the machine is this: The workman, holding by the handles, attaches them to the box, and directs the horses forward to the ground to be levelled, or rather an assistant may be employed to lead the horses forward. The workman at the handles in the mean time, by pressing them down, causes the box to move upon the heel C. But when he reaches the ground to be removed, by raising the handles he allows the sharp

Fig. 105.



edge of the box DD to penetrate into the ground: the horses in-

the mean time moving forward, the box is loaded with earth. By pressing again upon the heel C, this earth can be carried forward, as on a sledge, to the place where it is deposited. When the box arrives at this place, the man at the handles stretches them outwards, and disengaging the handles, allows the box to turn round as in the preceding figure, and in this manner the load is discharged.

The horses in the mean time moving forward, the box is caught on the ground by the projecting points EE, by which means it is again turned round and replaced in its first position. Thus the box carries its load from the elevation to be removed to the hollow to be filled, deposits it, and regains its former position, and this without the necessity of stopping the horses. The machine is efficient and expeditious in its operation. It may be advantageously employed for the levelling of those crooked and elevated ridges which are seen in so many places. But it is to be observed, with respect to the levelling of such ridges, that in all cases the soil should in the first place be removed, so that it may be replaced on the surface, and not buried.

The last impediment to tillage to be referred to is that produced by swamps, and other effects of water under ground.

The modes of removing this source of injury will be described under the head, Draining.

3. Paring and Burning.

The process of Paring and Burning consists in paring from the ground a thin turf or sward, burning the sods, and spreading the ashes upon the surface.

The operation is performed either by a species of spade, or by a plough with a broad share, so formed as to cut off a thin turf. The spade employed is triangular at the point, has usually a raised edge, as shewn in the figure, and is fixed to a strong shaft, having a cross handle at the end. This spade is pushed along partly by the hand and partly by the breast, and hence it is termed

a breast-plough. But it is now made to be pushed along by the thighs, for which end a board, or padding of wool, is used, upon which the handle presses.

Fig. 106.

The workman, when he has pushed the spade forward by the pressure of his hands and body for about two feet, suddenly reverses the sod. He thus continues, pushing the spade, and turning over the sod, as he advances; and workmen with similar spades following one another, the whole surface is turned over. The depth of the sod cut is usually from $1\frac{1}{2}$ to 2 inches or more. When there is no peculiar obstacle, a man will pare an acre in four days.

The breast-plough performs the work in a satisfactory manner, although with considerable force of manual labour; and when the ground is uneven, or in any degree rocky, it is the best kind of instrument that can be employed. But when the surface is level, as in the case of peat, or marshy grounds, ploughs suited to the work may be substituted.

The ploughs used for this purpose are variously constructed. They have handles and a beam like the common plough. Some of them cut in the manner of a Dutch garden-hoe; but the best of them are furnished with a very broad thin share, and a mould-board so formed as to turn the sod over flat with the grassy side underneath. The coulter is frequently made in the form of a wheel, which cuts the ground with less friction than the common coulter. In the fenny parts of Cambridgeshire, where the system is extensively practised, the ploughs are so well constructed that they will turn a furrow of from 12 to 16 or even 18 inches in breadth, and of a thickness of not more than an inch.

The turf being cut, it is set on edge; and after it has remained in this state for a time sufficient to render it dry enough to burn,

which is generally in two or three weeks, it is either set on fire as it stands on edge, or collected into heaps, which are set on fire and left to burn. These heaps are usually made like small haycocks, about three feet in diameter. They should be formed loose in the centre, but be closely packed on the outside, so as to render the combustion slow and gradual, in order that they may be entirely consumed. But there is often difficulty in getting the turf to burn, in which case it is necessary to employ furze, straw, faggots, or other substances. The process of preparing and burning the turf may be begun in April, if the season is dry, and continued throughout the summer and autumn as convenience, or the state of the weather, allows. When the heaps are burned, the ashes are spread abroad upon the surface, and covered by a shallow ploughing.

This operation, as a mean of calling into action the productive powers of the soil, has been long practised in England, in the marshes and heaths of Holland, and in some other countries, and has probably been derived from remote times. It does not appear that the Romans practised it. Virgil, indeed, says,—"It is often useful to set fire to barren fields, and burn the light stubble with crackling flames." But from the comments of the other rustic writers, it does not seem that any thing more was here understood than the burning of the stubble itself. Yet the practice may have been known in some parts even in Italy. Crescenzio of Bologna, the earliest writer on agriculture after the revival of letters, mentions it as a practice known to the inhabitants of the Alps. They pared off the surface of the ground, he tells us, dried, and burned it, and then, having sown siligo, they allowed the land to rest for eight years, when the operation was repeated.

The process, indeed, from the facility with which it can be performed, and its powerful and immediate action, may be supposed to have been adopted in the very infancy of agriculture, when it would be resorted to for a purpose of present profit, without reference to its ulterior consequences.

By this process, the vegetable matters of the soil are reduced

to ashes, in which state they are calculated, as in the case of other vegetable ashes, to produce a speedy, though not a very permanent, action upon the soil. The large quantity, too, of torrefied earth, mixed with the other matter of the soil, may in many cases be supposed to improve the texture of the mass, and render it more porous and accessible to the air of the atmosphere.

While it is by some contended that the process must exhaust the soil of its permanent sources of fertility, by dispelling the organic matter which it contains, it is maintained by others, that any loss of organic matter from this cause is more than balanced by the increased productiveness of the soil, and the consequent means afforded of adding to its fertility by the greater production of manures; and that, in truth, experience does not prove that the soil is impaired in its permanent powers of fertility by the process.

That a great portion of the vegetable matter of the soil is dispersed by the process must be admitted, and thus it may seem calculated to impair the permanent fertility of the mass. Yet there are certainly cases in which this loss of organic matter may be more than compensated by the improvement of the texture of the soil, and by calling more quickly into action its powers of production.

One of these cases is, when there is a large proportion of inert vegetable fibre, as in peat. Here there is not only an excess of vegetable matter, but this matter is in a state unfavourable to the nutrition of plants. The consuming of a portion of it, therefore, is not only to remove that which is useless or noxious, but to convert it at once into a fertilizing agent; while the mineral matter with which it is mixed increases that which is most wanted in a peaty soil, namely, the proportion of earthy matter. The burning, therefore, of a portion of the surface of peat is found to add to its present powers of production, and frequently to its permanent fertility.

Another case in which the practice of paring and burning has been frequently found to be beneficial, is that of cold coarse clays.

especially when they are of a marly nature. Here the organic matter of the soil may be in such small proportion, that the dispersion of it may be more than compensated by the present increase of productiveness, by the destruction of the seeds of weeds, and by the improvement of the texture of the mass, from the large quantity of clayey ashes mixed with it.

Another case in which the practice of paring and burning has been found to be attended with present benefit, is that of chalky or very calcareous soils. Certain chalky downs in England have been subjected for a very long period to this seemingly destructive treatment, without any apparent diminution of their fertility. It may be assumed, therefore, from the effect, that when such soils have been laid down to grass, the increased production of new sward has been sufficient to balance the loss of organic matter which the burning of the surface had produced. When the inhabitants of the Alps, referred to by Crescenzio, allowed their land to rest for eight years, they manifestly intended to allow time for the production of a new surface before they repeated the operation.

There is one case, however, in which the most eager advocates for paring and burning admit that injury is always produced by the operation. This is when thin siliceous soils are thus treated. Such a result, indeed, might be inferred. The torrefaction of the siliceous sand produces no amendment in the texture of the mass. It might do so in a stiff clay, which it would render more friable; but, in the case of a loose sand, this is not required, and would not be useful. Further, the scanty vegetable matter which such a soil contains being destroyed by heat, or exhausted by a few crops of corn, little remains beyond the barren sand of which the soil is composed,

And in all cases where paring and burning is practised, great injury may result from severe cropping after the operation. The temporary fertility produced may afford the injudicious farmer the means of reducing the finest soil to the greatest degree of sterility.

The beneficial effects of paring and burning may be admitted in many cases, when it is employed to render certain kinds of land arable for the first time. Then it is a ready instrument of production; and it is applied in a case where the farmer must calculate narrowly the profit and the loss. It is of such great importance, that the first crops on newly reclaimed land shall be such as speedily to replace the expenditure, that the application of a powerful stimulus like paring and burning may seem to be justifiable and proper.

But when the practice of paring and burning is employed periodically, as part of a system of farm-management, to stimulate the powers of land already brought into cultivation, the practice does not admit of a like defence; nor does all the authority of many eminent agriculturists in different parts of England invalidate the opinion that the practice is useless in many cases, and unsafe and injurious in others.

We are referred to the example of the districts of the Fens, where the system is largely practised, as a proof of its advantages. But even were it shewn to be advantageous in the case of these deep fens, this would prove nothing with respect to its applicability to the great mass of the cultivated soils of the country. These fens consist of peat, which having been formerly submerged in the ocean, is largely mixed with earthy matter. No soils precisely similar are to be found in other parts of the kingdom; and they are the soils in which, of all others, the process of paring and burning is calculated to produce a high degree of present fertility, without sensibly diminishing their future productiveness, especially if they shall be laid to grass after incineration, and thus permitted to recover a new sward. Under the system pursued, it is said, the farmers of the fens raise great crops; but are we to forget the surprising depth and fertility of these marshy soils, and that under any tolerable system of cultivation large crops would be produced upon them? But if we shall turn to Flanders, where such a system as paring and burning is never thought of, we shall find that a far larger amount of food is produced by a regular succession of crops, and by a due collection

and preparation of manures: or, let us refer to the better soils of the north of England, and of Scotland, where, by means of a proper system of tillage, a larger produce is raised than in the rich district of the fens, under all the disadvantages of a colder and more variable climate. Besides, to what kind of management does this system, in the greater number of cases, give rise? The land being broken up and stimulated by this rude process, must be laid again to grass, in order that it may produce a fresh sward, and thus recover its wasted powers of production. Would it not be better that it should be kept in a regular course of cropping, and in this manner maintained constantly productive, instead of being stimulated at one time, and left to nature to restore itself at another? The case of calcareous soils, as those of the Cotswold Hills and the southern Downs of England, is likewise cited as evidence of the benefits of paring and burning. But the system pursued in these cases would not deserve imitation, even were it applicable—which it is not—to soils deficient in calcareous matter. The lands in question are doubtless rendered at once productive by the process; but then, in order to restore them, they must be laid down to grass, to bear inferior herbage for several years, until they shall be again ready to be cropped and scourged. In many of the finest parts of England, we may see the great injury resulting from the indiscriminate practice of this system periodically pursued; and in the south of Ireland the matter is yet worse; for there we find tracts of land that might be maintained in the highest degree of productiveness by good management, alternately stimulated and robbed in a degree which takes from them half their value.

The system of paring and burning, then, seems to be only admissible, in any case, as a *first* improvement; or, if ever land is pared and burned a second time, it should only be on account of some peculiarity of circumstances, which the judgment of the farmer must determine. Almost the only cases in which it may be safely employed seem to be,—

1*st*, In the case of poor cold clays, marls, and calcareous soils, when broken up for the first time.

2d, In the case of moors, where there is a considerable stratum of peat, and which are broken up for the first time.

3d, In the case of deep peaty soils, where the vegetable matter cannot be exhausted.

4. Draining.

Principles to be ever observed by the farmer are to keep his land dry, rich, and clean. The first in order of these principles, and an essential one to be regarded in cold and humid countries, is to keep the land dry.

The water contained in the soil, may either be retained by the particles of earth by cohesion, or may fill its pores and interstices, unable to make its escape. In the latter case, the soil is saturated beyond the wants of plants, and in the colder countries this excess of water is one of the causes of infertility. In land thus surcharged with water, the seeds of plants frequently perish, or else their growth is retarded; putrescent manures decompose more slowly, and those of mineral origin exercise a less useful action; and when the saturation takes place in the months of winter, the soil, in the language of farmers, becomes soured, and a period of the warmer season elapses before it acquires the temperature favourable to vegetation.

When water falls from the atmosphere, it tends to sink into the ground. When it falls in such abundance, or with such rapidity, that the earth cannot imbibe it, the excess tends to flow along the surface, forming channels, streams, and rivers, which carry it to the great receptacle of all the waters of the globe, the ocean. Sometimes it is first carried into lakes, swamps, and morasses, whence it either finds its way by rivers, or by channels under ground, to a lower level, or else is carried up again to the atmosphere by evaporation.

From all the surface of the land and seas, water is continually ascending into the atmosphere to be again deposited on the surface, and thus, by a grand process of circulation, the wants of

living plants are supplied. But often, after it has been deposited on the surface, or sunk into the earth, it tends to accumulate in the cultivated ground; and then the art of the drainer is required to remove the excess. Channels are accordingly formed to convey it to some suitable outlet, whence it may find its way to the stream or other recipient to which it would naturally flow.

The water to be carried away may be either that which stagnates, or tends to stagnate, upon the surface, or that which having already sunk into the earth is retained, or is finding its way by natural channels under ground to a lower level. The removing of water yet upon the surface, is termed Surface-draining; the removing of that which has sunk into the earth, is termed Underground-draining.

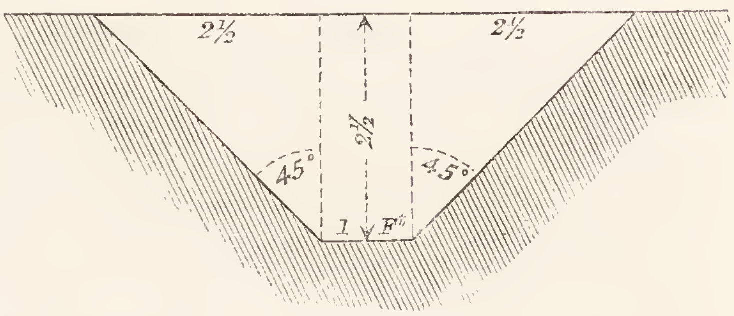
The ordinary drains for conveying away the water of the surface are, 1*st*, The ditches of fields, which should be so laid out as to collect and carry away the water of the cultivated grounds; 2*dly*, The water-furrows of ridges, which are rendered subservient to the same end; and, 3*dly*, Artificial channels or trenches dug in the places necessary for allowing a passage to the water collected on the surface.

It is to the latter class of channels that the term surface-drains is more peculiarly applied. They are laid out in the direction best suited to carry off the surplus water above ground. They are for the most part formed in hollows, because it is to them that the water upon the surface naturally tends. Sometimes they are made along the higher grounds, to intercept the passage of water to the lower, and sometimes they pass from the higher grounds to the lower, so as to form channels of communication between them.

The drains of this class are generally kept open, and then they are always formed with an inclination of the sides from top to bottom; and, in order to prevent the crumbling down of the sides, this inclination should never, except in the cases of rock or very hard earth, be less than 45°; and when the earth is very soft and boggy, the sides should possess a yet greater slope. In order that the sides may incline at an angle of 45°, the width at

the top must be equal to the width at the bottom, and twice the depth, as shewn in the diagram, Fig. 107.

Fig. 107.



The earth taken out of the trench should be thrown or wheeled carefully away from the sides, so that it may not press upon them, or prevent the water from finding its way into the drain from the adjoining grounds. This earth may be spread equally upon the nearest ground, or employed to fill up hollows where these exist; and sometimes, when it is much mixed with vegetable matter, it may be employed to form composts with lime and other substances.

As the direction of such drains depends upon the form of the surface, so their size depends upon the quantity of water which they are to carry away. A medium size of the ordinary open drains of the farm may be 6 feet wide at top, 1 foot wide at bottom, and 2½ feet deep.

There are cases, however, in which the channels must be of a larger size, dependent upon the quantity of water which they are to contain. Thus, in many of the flat districts in the eastern counties of England, the surface of which is scarcely raised above the level of the sea, the ditches are frequently of such dimensions as to contain the excess of water which is carried to them, in the manner of ponds or little canals. Cases, too, frequently present themselves, in which it is necessary to deepen existing rivulets, or form new channels; but these are to be regarded as cases of engineering rather than of the ordinary open drains of the farm.

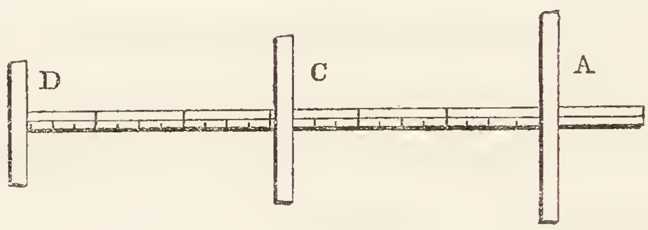
In the formation of common open drains, little difficulty will present itself. Their direction will be indicated by the form of the surface, and the particular end which they are designed to serve, and their size by the quantity of water which they are to transmit.

The instruments employed in this species of draining are—

1. A rule and line, such as gardeners use, for laying off the lines of the sides.

2. A simple instrument for measuring off the width and depth of the drains, and which consists of a piece of wood divided into feet and inches, having another piece of wood A sliding upon it, and at right angles to it, and two other pieces, C and D, fixed upon it.

Fig. 108.



3. A common spade, Fig. 61, and a narrow-pointed shovel, Fig. 63, for digging and throwing the earth from the trench.

4. A mattock and foot-pick, Figs. 64 and 65, for loosening the harder earth, and raising up stones and other impediments.

5. A wheel-barrow, in the cases where wheeling is required.

Further, the farmer should possess a common spirit-level, for determining the fall of water from one point to another.

It is the province of the farmer to fix the general line and medium dimensions of the drain, but the workman, as he proceeds, attends to the minor variations of depth, so that the water may not stagnate at any part; and he always begins at the lower part of the ground to be drained, working up to the higher, in order that the water may flow away from him as he works.

The drains of this class are often, as has been said, to be kept open; but sometimes they are partly filled with stones, or other hard substances, in order that the plough and other instruments of tillage may pass over them without interruption. In this case, it is intended that the water shall sink through the ground into the drains, and then the method of their construction is the same

as that of the next class of drains to be considered, namely, under-ground drains. In certain cases, the drains of this class are arched, or otherwise built with masonry.

Water, it has been said, falling upon the surface, tends, in so far as it has not been absorbed, to seek a lower level, either spreading along the surface, or being confined to natural or artificial channels. But a great part of the water which falls upon the ground, sinking into it, is either retained by the particles of the earth by cohesion, or fills its interstices, or finds a passage for itself under ground.

Water not only tends downward by the force of gravity, but it tends to follow the course of the earthy or rocky strata on which it impinges. If any stratum which it reaches in its descent be hard or impervious, it will percolate along its upper surface, in the same manner as it would upon the surface of the ground. The course which it naturally seeks for itself, is that in which it is the least resisted, namely, in those strata, or interstices of strata, which are most loose and permeable.

The surface of the earth, and the superficial as well as deeper deposites, follow various directions; but their general tendency is from the higher to the lower parts of a country; hence the general effect of the stratified structure of the mineral masses of countries is, to cause the water which has sunk into the earth, to find its way from the higher grounds to the level of the sea; and the same principle which regulates its conveyance to the general receptacle of all water, the ocean, above ground, regulates its transmission to the same vast magazine below ground. But beneath the surface of the earth, as above it, there are the sources of deviation and obstruction; and it is chiefly when these present themselves, that the art of the drainer is required to form new channels for the water, so that it shall not overflow the surface, or saturate the soil.

Should the subsoil be hard or clayey, the water that sinks through the soil will be resisted by the surface of the subsoil, and tend to flow along it. In this case, the stratum through which the water percolates, will be the soil itself, which will be kept sa-

turated by water unable to find its way downwards. A common cause, accordingly, of the wetness of the soil, is the tenacious nature of the subsoil.

If, again, the subsoil is loose and pervious, the water will sink down by its own gravity until it is resisted by the surface of some harder stratum, or until it arrives at some pervious seam or channel in which it can percolate freely. Soils, accordingly, which have a loose or pervious subsoil, are those which are the least apt to be saturated by an excess of water.

The greater or less inclination, too, of the subsoil, or other substance which resists the descent of water, has an important influence on the wetness or dryness of the soil. If the surface is very flat, the water will find its way more slowly than when it has a descent; and if the surface is hollow or basin-shaped, the water will lodge in it as in a pond.

The seams or beds beneath the surface through which water percolates freely, are sand, gravel, decomposing rocks, or looser substances of any kind. Those which resist the percolation of water, are clays and the harder rocks.

The seams found in the softer covering of the earth, vary from less than an inch to a foot or more in thickness. If they consist of sand, gravel, decomposing rock, or any loose substance, they are termed by drainers pervious: if they consist of clay, or any harder matter which resists the ready passage of water, they are termed impervious. It is in these pervious seams that the water under ground is to be found in the greatest quantity, and they form the principal natural channels through which it percolates in passing from a higher to a lower level.

These seams are familiar to all who are in the practice of draining, or sinking wells. It is from them that the water under ground is seen to ooze or flow out in cutting through them. It is common, in draining and the sinking of wells, to penetrate to a considerable depth without finding water in any quantity, when on reaching one of those pervious seams, it is found in excess, and often rushes forth like a fountain. Well-diggers, on reaching these conducting channels, have sometimes difficulty in sav-

ing themselves from the rapid flow of water into the well. It is because the water is proceeding from some higher source that it rushes up when these channels are opened. It is often necessary to dig to a great depth before water in sufficient quantity for domestic and other uses can be obtained. Great quantities of the purest water are obtained in London from wells sunk through the vast body of clay on which the city stands. Some of these wells are from 200 to 300 feet in depth. In all the inhabited warmer countries, wells have been sunk, and the water raised from the deep channels through which it pursues its course. In France and Italy, the attention of engineers has been in a peculiar manner directed to the obtaining of water from wells of an extraordinary depth, termed Artesian. In these, the water rises often above the surface in a continued stream, shewing that it has been derived from an elevated source, as in the plains of northern Italy and France, from the distant Alps and Pyrenees.

The water which thus percolates in natural channels beneath the surface, may be so far below the soil as to pursue its course without affecting the cultivated plants. But often the water in its subterraneous channels is brought so near to the surface that it is imbibed by the subsoil and soil above it; and often the channels themselves, being interrupted under ground, or coming to the surface, form swamps and springs, which sometimes overflow or saturate a great extent of ground.

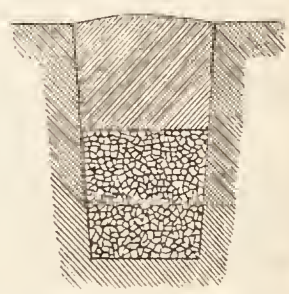
The soil, then, may receive an excess of water, either from the rain which falls upon the surface being unable to make its escape, or from that which has already sunk into the ground reaching again the cultivated soil.

Two methods may be adopted for remedying the injury produced in either case. The first is the forming of outlets near the surface for the water which is in excess; the second is the reaching it in its deeper channels so as to intercept it, and confine it to some determined course. The former method is the most easy of execution, and is often the only one that can be practised on account of the nature of the subsoil: the latter demands more experience and care, and calls for the application of principles

which are only partially observed in the other. We will first consider the simpler system, in which the drainer merely seeks to form outlets for the water which may saturate from any cause the ground near the surface.

In this, as in other kinds of draining, the channel for receiving and conveying away the water consists of a narrow trench, in the bottom of which are placed stones, tiles, or other substances, so disposed as that the water which finds its way into the trench shall flow along it, and be conveyed to some convenient outlet. Above these materials is thrown the earth which has been taken out of the trench, so that while a passage is left for the water in the drain, the plough and other instruments of tillage may pass over it without impediment.

Fig. 109.



The trench varies in depth with the nature of the subsoil and soil, and the materials employed in filling. In all cases there should be a depth of earth above the materials in the channel of not less than 16 or 18 inches, so as to place the materials beyond the reach of injury from the deepest ploughing, or from the feet of the animals of labour. The entire depth of the trench, therefore, will depend on the space occupied by the materials which form the channel. When tiles are used, the depth of the trench may generally be from 24 to 30 inches; when stones are employed, the depth may be from 2½ to 3½ feet, and in certain cases more. The breadth of the trench at top and bottom may be as narrow as a man can conveniently work, or as consists with the nature of the materials employed, the efficiency of the drains depending upon their depth, and not upon their width.

The workman, in forming the trench, begins at the lower part of the ground, and works up to the higher, so that the water may flow continually from him as he works. The instruments employed are those which are used in the case of the open drain, with the exception of the wheelbarrow,—namely, the reel and line, and the measuring-rod, but chiefly the spade and shovel, the mattock and foot-pick.

The most durable material for filling drains, is stones. These may be sandstone, whinstone, or any of the harder rocks. They should be of moderate size, as from 1 lb. to 2 lb. weight, and when very large, they should be broken into fragments. They may either be quarried or collected from the surface of the fields. River gravel, or gravel of any kind sufficiently cleaned from intermixed sand, is well suited for the purposes of draining.

The stones may either have been brought forward while the trench was in the course of being formed, and emptied directly from the carts into the drain; or, what is better in most cases, they may be laid along the side of the drain, and thrown into it by the hand or shovel.

They are thrown promiscuously into the trench, but when the drains are of considerable depth, it is regarded as beneficial to form a conduit at the bottom. This may be done by building a wall with a few stones roughly, but solidly, on each side at the bottom, so as to form an aperture of 5 or 6 inches square. The remaining stones are then thrown in promiscuously to the height required; but in place of the walls of stone, for which the suitable materials cannot always be found, there may be used a series of arched tiles placed upon their soles in the manner to be afterwards mentioned.

When the stones are thrown into the drain, they should be carefully levelled and packed at top, and covered with some substance to prevent the falling down of the loose earth shovelled in. Nothing answers this purpose better than the sod which had been taken from the top of the trench, laid upon the stones with the grassy side underneath. But when no sod has been reserved, straw, heath, ferns, tanners' bark, smithy ashes, or any similar substances, may be employed. A thin layer of these being spread upon the surface of the stones, the earth which had been taken from the trench is thrown into the drain. This may be done by the spade or shovel, though frequently, for economy of labour, the plough is employed.

In a drain formed in this manner, the stones resist the pressure of the earth, and their interstices afford numerous channels by

which the water finds a passage. These channels, indeed, are apt to be filled by the deposition of mud; but the water continues for a long time to preserve for itself the channels which had been once formed for it, in the same manner as in the natural channels which it had made for itself under ground. The advantage of a conduit at the bottom, however, is, that it affords a larger and more regular channel, less apt to be silted up by the deposition of mud.

The best condition of the land for the forming of drains is when it is in grass, because then the looser soil is less apt to be carried into the drain when first formed; but we cannot always choose our time of draining, and must frequently adopt that which is most convenient in other respects.

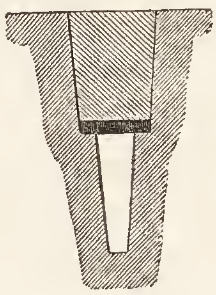
Stones or gravel, although the most durable materials for drains, cannot always be obtained, and then substitutes must be employed. Branches of trees, brushwood, furze, and similar substances, may be used; but these are far inferior to stones in usefulness and durability. They resist, indeed, the pressure of the earth from above, and thus afford a freer passage to the water; but they decay after a time, and the drain may be choked, although very often the channels that have been worn by the water remain permanently after the woody materials have decayed.

In certain cases, foreign materials have been dispensed with, and a passage formed for the water by various means. One of these consists of a simple perforation made below the surface by means of a cylinder sharpened to a point, attached to a coulter or vertical bar of iron, moved along in the manner of a plough. The instrument, termed a Mole-plough, is chiefly employed in old pasture-grounds, and, by forming a narrow tube for the water, produces a certain degree of benefit. This species of draining, however, has not extended in practice, and, though economical, is not to be compared for efficiency with the other methods employed.

Sometimes a species of draining termed wedge-draining has been adopted. The method of forming it is to make a narrow

trench with a long narrow shovel. The spit being taken out as deep as the shovel can go, a scoop is employed to clear out the mud and loose earth at the bottom. Then another spade, narrower than the first, is used, and a second spit taken out; and, lastly, a corresponding scoop, to clear the whole out,—forming a trench with a ledge, as in the figure.

Fig. 110.



A piece of sod, with the grassy side below, is then forced down, and, resting upon the ledge, a space is left for the water below. Sometimes the ledge is dispensed with, and the sod is merely formed into a wedge, narrowed toward the grassy side; and this, when the little trench is cleared out, is pressed into it, and covered with earth; and as it does not reach the bottom, a channel remains below, through which the water percolates.

This simple species of drain, of which there are several varieties, has been extensively adopted in some districts; and as it is easily formed, and as the number of drains may be multiplied at little expense, considerable benefit has resulted from the use of it. But although drains of this kind will sometimes remain open for a considerable time, they are exceedingly apt to be closed up, and are only suited for land kept permanently in grass.

Greatly the best substitute for stones is tiles, moulded into the form required. Tiles had been long partially used for draining in certain clay-land districts of England; but the use of them has now extended to most districts of the country, even where stones can be procured in the necessary quantity.

The tiles employed in draining are formed of clay moulded into the form of an arch, and then baked in the kiln in the usual manner. For each tile (*a*, Fig. 111), there is formed a flat sole (*b*) of the same material, on which the arched tiles rest in the manner shewn in Fig. 112, and of a breadth to extend about half an inch on each side of the tile. Each tile, with its corresponding sole, is from 12 to 14 inches long; and the size of the arch varies with circumstances. The usual dimensions are from 3 to 4 inches wide

within, and from 4 to 5 inches high. But the tiles for the main drains, which are placed to receive the water from a number of smaller ones, are made of a larger size, as 6 inches wide within, with a corresponding height.

Fig. 111.

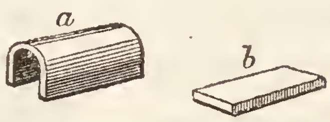
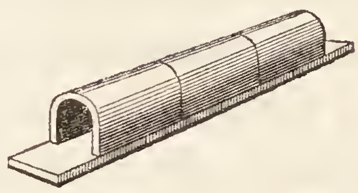


Fig. 112.



The water finds its way into the conduit by the interstices at the junction of the arched tiles with one another and with the soles; and it is found that, when proper precautions are used, the water oozes readily through these narrow passages into the channel prepared for it.

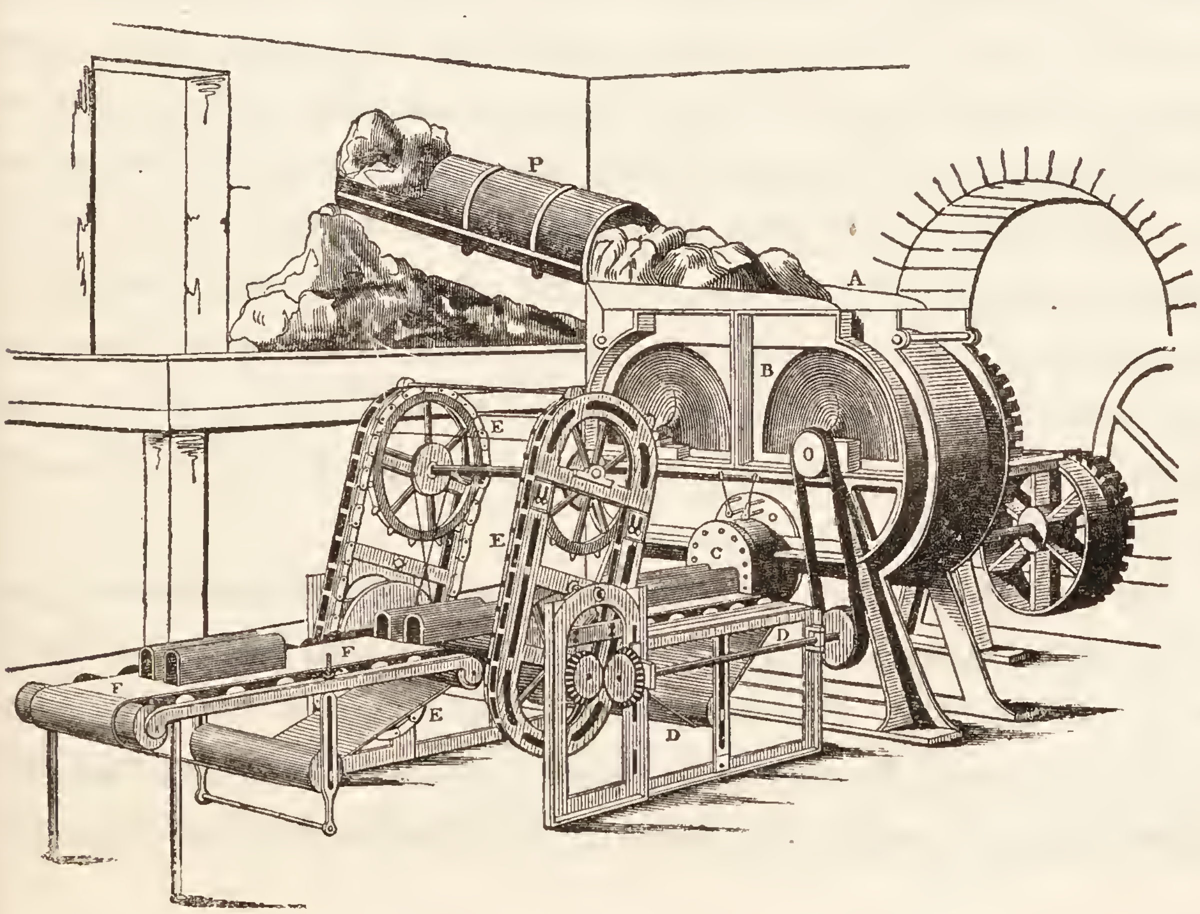
The clay of the tiles is first made flat, and then bent into form on a mould by manual labour; but recently, machinery has been employed for performing these processes. Of the machines introduced for this purpose, one is that of Mr John Ainslie, who has obtained a patent for his invention.

The machine possesses a hopper, into which the clay is conveyed from a pugmill, as it is termed. The pugmill is a cylindrical vessel, through which passes a spindle with arms at right angles to it carrying knives, the use of which is to cut and prepare the clay. But when the clay is free from intermixture, the pugmill may be dispensed with, the clay being at once carried to the hopper. From the hopper the clay is conveyed to two rollers set very closely together, between which it passes, and which comminute and reduce to powder any hard substances which may be mixed with it. Immediately underneath the opening, beneath the rollers, is placed a cylindrical vessel with a narrow opening through which the clay enters. Within this cylinder revolves a screw, with two threads about 7 inches apart. When the rollers force the clay between the threads of the screw, the screw revolving forces the clay into a chamber in front of it. To the fore part of this chamber is screwed a plate, having apertures of the form of a cross section of the tile to be made, so that the

soft clay is forced through the aperture in a continued stream. In this manner the arched tile of the form required is moulded, or when soles are to be made, an aperture of the required form is substituted. In front of the plate is placed an endless cloth, which receives the moulded clay from the aperture, previous to its being cut of the required length. In front of this cloth is placed a frame carrying rollers, over which work two endless chains, one on each side of the frame, which divide the clay. The chains have an inclined and not a vertical motion, so that the wires are enabled to cut the clay vertically during its continuous movement. The tiles thus formed and cut, are continued to be pushed forward by the uncut clay over small rollers, until they reach another endless web, by which they are carried forward, and from which they are removed by the workmen and placed at once in the drying frames, which are furnished with wheels, so that they may be brought to the sides of the machine.

The following figure represents the machine with the pug-mill attached. P is the pug-mill laid with a slight inclination. A is the hopper into which the clay is received from the pug-mill. BB are the pressing rollers between which the clay passes. C

Fig. 113.



is the mould-plate, forming the front of the chamber, into which the clay is forced by the screw. D D is the travelling canvass on which the tiles are received on leaving the mould-plate. E E E E are the endless chains working over pulleys, and carrying the cutting-wires, which are so disposed as to cut the clay of the proper length, and make the section vertical. F F is the travelling canvass, to which the tiles are conveyed by the small roller, and from which they are lifted by the workmen, and placed in the drying-frame.

By this simple machinery the tiles can be formed of any shape and size, and the injury is avoided which is caused to them by the common process of bending them from the flat state into an arch, The same machine may be employed not only for forming tiles for draining, but for roofing and any other purpose to which tiles are applied. It in like manner can form building-bricks of any shape, with a precision, despatch, and uniformity of texture, which cannot be attained by the ordinary methods. The machine here described has lately been much simplified.

In place of tiles formed by baking, it has been recently proposed to make use of a concrete, consisting of lime, fine sand, and gravel. The proportions recommended to be employed are,—1 bushel of unslacked lime, 2½ of sand, and 4 of fine gravel. The materials being duly mixed and worked up with a little water, are placed in square moulds of wood, open at one side. Being pressed firmly down, there is passed along the surface a heavy iron cylinder, of the size of the arched aperture to be formed, aud then, by means of cutting-wires, the concrete is divided into lengths in the manner of tiles. The separate pieces being then removed, are either left for several months to dry and harden, or they are put into the drain on being made, and being covered with earth, are left to harden.

Another substitute, too, for tile, has been proposed and partially adopted, consisting simply of square boxes, formed of larch, or any of the more common and cheaper kinds of fir. The sides of the boxes are loosely put together by wooden pegs, and perforated so as to admit the water. It is probable that this kind

of conduit will have a sufficient degree of durability, and may be usefully adopted in cases where the thinnings of plantations can be obtained at a low price.

In the drain formed by tiles, it has been seen that the water of the soil oozes into the channel formed for it at the junction of the arched tubes with one another and with the soles, and that there is only one channel through which the water flows, in place of the numerous though less regular passages, where stones are the materials used.

The soles on which the tiles rest are frequently dispensed with; but this, in the greater number of cases, is an error in practice. The use of the sole is to prevent the sinking down of the superimposed tile, to retain it steadily in its place, to keep the channel clear of mud, and prevent injury from animals under ground. Even the stiffest clays tend to crumble down under the influence of moisture and the air which fills the conduit, and vast numbers of drains have become useless after a short time, from the want of these supports.

Slates may be used for soles in place of tiles, and even deals or battens of any common kind of wood, of which the best is larch. Soles of wood are exceedingly well suited for soft and boggy ground, because, being made of considerable length, they are less apt to be pressed into the soft earth.

To promote the efficiency of the tile-drain, as free a passage as possible must be allowed to it for the water in the ground. To this end, the sod which had been taken from the top of the trench should be laid aside, and placed upon the tile, so as to overlap it. When no sod exists, the looser earth of the surface should be laid upon the tile, and upon this the more tenacious subsoil. But when the tiles are placed at some depth, it is always highly important, and in some cases essential to the efficiency of the drain, that there shall be placed over the tile a foot or more of broken stones, gravel, or any looser materials which can be obtained.

The trench for receiving the tiles is first formed by the common spade, using the foot-pick or mattock when necessary; then

there is employed the narrower spade, shewn in Fig. 113, so as to form the trench with a slope to the bottom, where the width should be just sufficient to receive the soles of the tiles; and in order to clear out any mud or loose earth in the trench, there may be employed the species of scoop shewn in Fig. 114. Sometimes, when the drains are very deep and narrow, two sets of spades and scoops are employed, as in the figures.

Fig. 113.

Fig. 114.

Fig. 115.

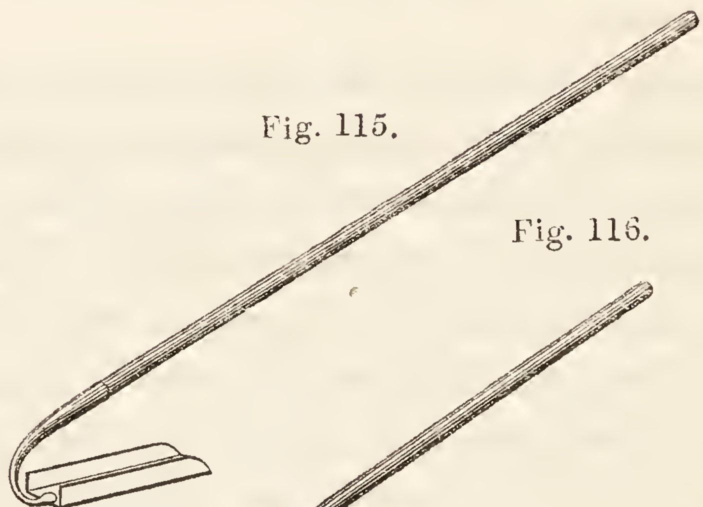
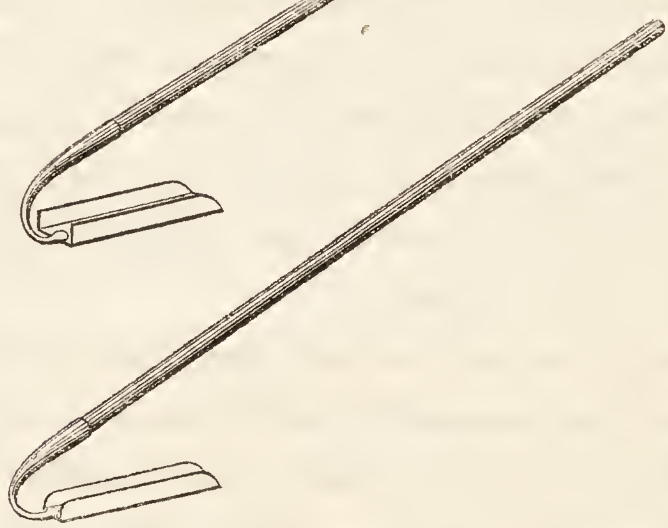


Fig. 116.



The trenches being formed, the tiles are laid in the bottom, and it is proper that each trench should be completed before the tiles are begun to be laid. The workmen, in laying the tiles, begin at the higher part of the trench, the tiles having been previously laid along the line of the drain. They work backwards, and there is an assistant to hand the tiles to the person in the trench. This part of the operation must be performed with care, so that the soles shall be placed firmly and evenly on their bed, and so that the declivity shall always be sufficient to cause the water to run freely. In shovelling back the earth upon the tiles, it is of primary importance to observe that the sod or looser soil of the surface is laid next the tiles; for which reason it is always better that the first portions of the earth be thrown in by the spade or shovel rather than by the plough, as is sometimes, for the sake of

economy, practised. To this end, the soil and loose earth should be thrown to one side of the trench, and the subsoil to the other.

We are next to consider the manner of laying out the drains, whether the materials employed shall be stones, tiles, or any substitute; and it is to be remembered, that we are here considering that kind of draining, in which we are not endeavouring to reach the water in its pervious channels, but simply opening channels for it near the surface, by which the excess may be discharged.

In the laying out of drains for this end, there must be always formed in the lower ground one or more outlets to which the different drains may be conducted, either directly or through the medium of leading drains.

When the ground to be drained is nearly flat, the trenches must follow the direction in which the water will run, and which will usually be that of the ridges. When the surface is inclined, the trenches may either run directly up and down, that is, in the line of the descent, or diagonally, that is, in some direction oblique to it. Certain conditions of the ground may render either method the most expedient. The soft alluvial covering of the earth has been very generally deposited in horizontal layers. In this case, the running of the trench longitudinally in the line of the descent is calculated to cut through the edges of the different seams, and thus to give a ready egress to the water which they contain; and in this condition of the surface, the horizontal direction of the trenches will be found to be most efficient. In other cases, the seams are not horizontal, but follow the direction of the surface itself; and in all cases, the upper surface of the subsoil, which resists the descent of the water into the ground, follows the direction of the surface. In such a case, it would appear, that, in order that the smallest number of trenches shall intercept the greatest quantity of water percolating from the higher to the lower ground, the trenches should not run directly in the line of the descent, but in some direction oblique to it. This conclusion is conformable to observation, for, in many cases, it is found, that a single drain crossing a descent, will render a large part of the field below it dry; and there are few cases in which a series of trans-

verse drains, at a given distance from one another, as 20 or 30 yards, will not effect a thorough drainage of the ground.

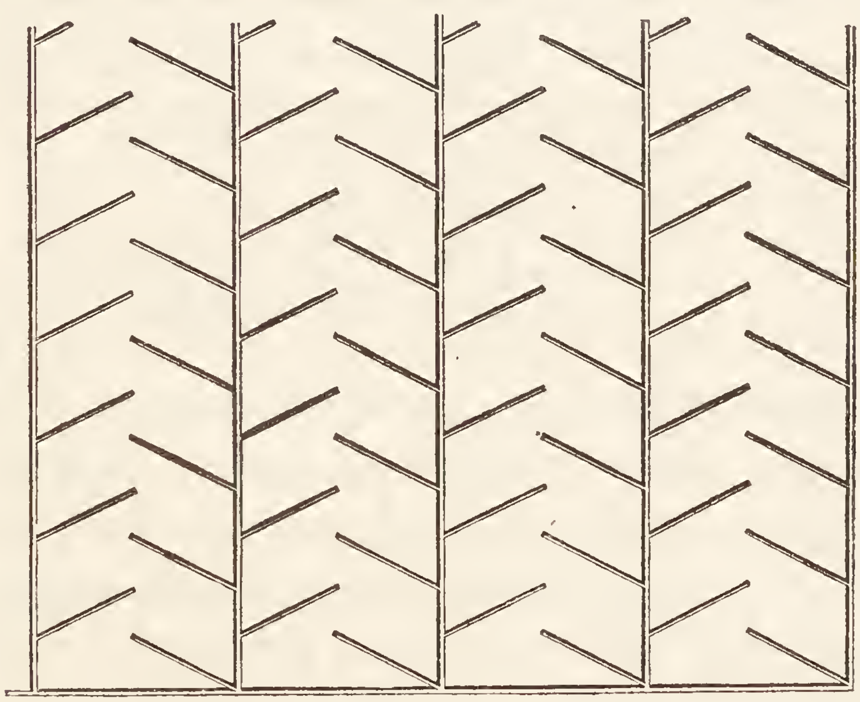
Strong opinions, indeed, have recently been expressed, that drains should, in all cases, run directly up and down the line of the descent. Drains run in this manner will, in almost every case, render the ground dry, provided they are sufficiently multiplied; but the question is not, whether a sufficient number of drains in the line of the descent will dry the land, but whether a smaller number of drains, carried in a direction oblique to the descent, will effect the object. That, in many cases, this will be so, is conformable to observation. It is common to run drains in the line of the descent, at distances of 15 or 18 feet. This may be expected, in every case, to effect a thorough drainage of the ground; but experience shews that a much smaller number, carried obliquely to the line of descent, will often accomplish the same end.

One purpose equally served by either course of the drains, is founded upon a principle which merits the greatest attention. A drain, in the language of farmers, is said to *draw*, which means that it renders the land dry on either side to a certain distance. The water under ground, it has been said, is either retained by the particles of the earth by cohesion, or fills its interstices and pores. Now, when a trench is formed of any kind, an outlet is opened for the water pent up in the pores and interstices nearest to the trench. These being emptied, the interstices of the earth, further remote, are likewise emptied into them, and so on to the greater or less distance to which the drain is technically said to draw. The opening of a trench in almost any direction causes an underground flow of this kind towards the channel, and to a greater or less distance from it, according to the more or less pervious nature of the subsoil. A drain carried directly up and down a descent will draw to a certain distance on each side of it; a drain carried across a descent will have an equal power at each individual point of that drain. There seems, in this respect, therefore, to be no superiority possessed by either disposition of the drains. The up and down drain may have the advantage in cutting a greater number of seams when these are horizontal; the transverse ones

of intercepting a greater quantity of water between the soil and subsoil, or when the seams are not horizontal.

The advocates of either opinion have doubtless carried their own principles too far, and made a too indiscriminate application of them in practice. In many cases, it is believed, a combination of the two principles may be beneficially adopted on inclined surfaces. A certain number of drains may be run in the line of the descent, and parallel to one another, and into these the cross or transverse drains, with the necessary inclination, conducted as in Fig. 117. In moderately inclined ground, the average distance of the longitudinal drains may be 100 yards, and that of the cross drains from one to another 30 yards or less, according to the nature of the subsoil. The trenches of the longitudinal drains should be 4 feet deep, those of the transverse drains not less than 3 feet, so that when tiles are the materials employed, a quantity of stones, gravel, or other porous materials, must always be laid above the tile.

Fig. 117.

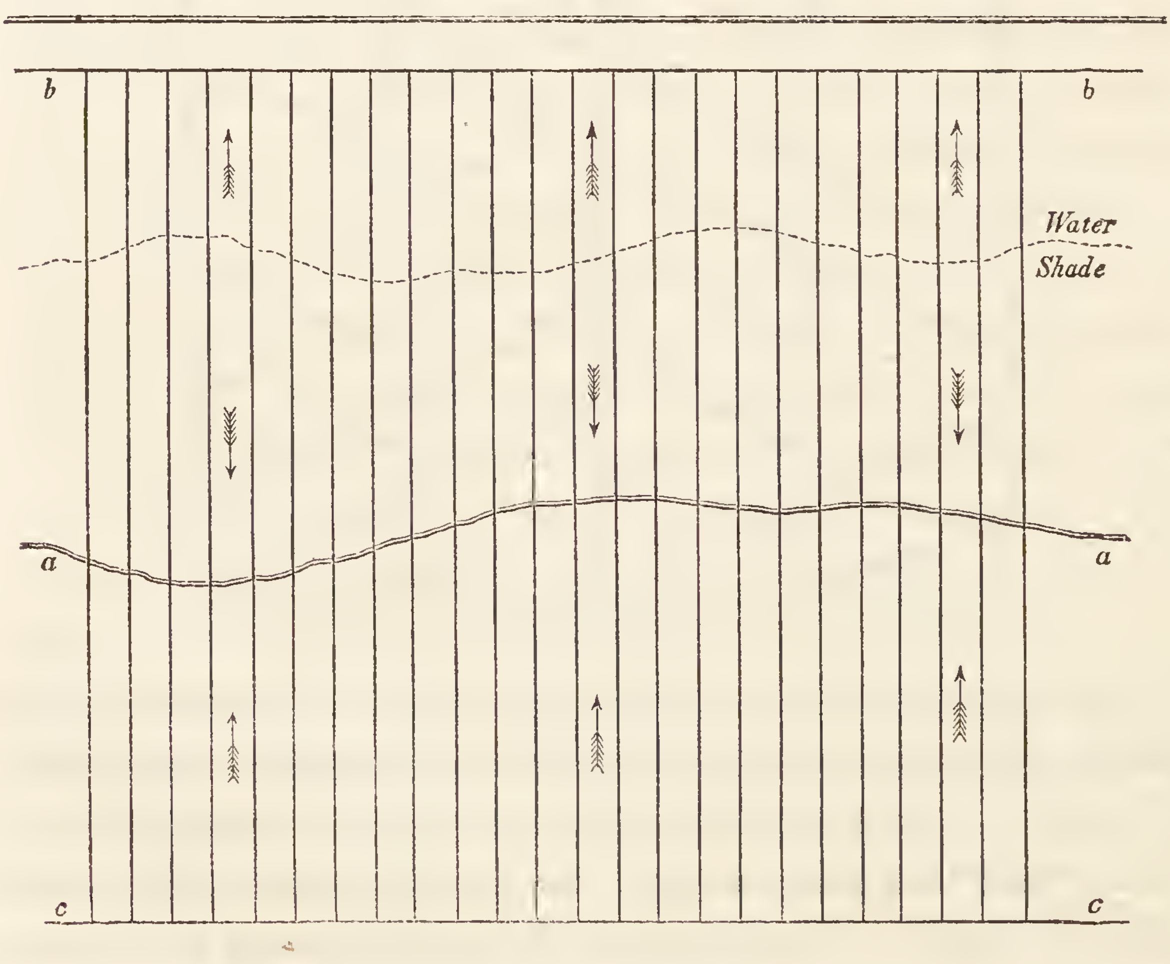


It is conceived that, in many cases, this disposition of the trenches will be more efficient, and consequently more economical, than when the drains are all run in one direction along the line of descent; and that there are few cases of a considerably inclined surface, in which an equal extent of trenches laid out in this man-

ner will not be as effectual as a similar extent of trenches laid out in the other.

But when the surface of the ground is flat, or moderately inclined, then the whole lines of drains may be laid out in the line of the ridges, which, in such a condition of the surface, are, or ought to be, in such a direction as will allow of a flow of water along the water-furrows. And, further, as the water-furrows themselves are the lowest parts of the ground, and as it is to them that the water naturally flows from the surface of the ridges, the drains themselves may be placed in these furrows. It is on this principle that the variety of draining, now the most generally practised, is founded. It consists simply in the forming of a series of small drains along the water-furrows of the ridges. It was formerly termed the Essex system of draining, from its having been first adopted in that flat and clayey district. It is now more commonly termed furrow-draining, which sufficiently indicates its general nature. Some have more recently chosen to term it thorough-draining, which, however, is scarcely so appropriate, since effectual or thorough-draining may be accomplished by a different arrange-

Fig. 118.



ment of the trenches, and even by the application of entirely different principles to the removal of the causes of wetness.

The principle adopted in the laying out of this class of drains, is to form receiving-drains, as *a a*, in the hollows of the ground, and to conduct into these the minor drains which follow the course of the ridges. There is usually formed a cross drain, *b b*, near the ditch at the higher part of the field to be drained, and sometimes another receiving-drain, *c c*, near the ditch at the lower part of the field, into which the minor drains are carried, in place of being conducted directly to the ditch.

Stones may be employed in this species of draining, as in every other; but tiles are more generally adopted, as being more convenient with respect to carriage, and as admitting of a smaller trench. The ordinary size of the tiles, it has been said, is from 3 to 4 inches of span within, though sometimes they are made of a somewhat smaller diameter. The tiles of the receiving-drains are of larger size; and sometimes two of the common kind are placed together, either side by side, or with their edges together, so as to combine their two arches into one tube, and sometimes three tiles are employed, as in the following figures.

Fig. 119. Fig. 120. Fig. 121.

The minor drains are carried to these receiving-drains, and the water is permitted to enter by chipping off the corners of the larger tiles at the place where the smaller drains terminate; but it is better that tiles for this particular purpose be prepared at the tile-work, in which case the apertures can be made either in the sides of the tiles or at the corners. The trenches of the receiving-drains are made a little deeper than the minor ones, so as to produce a current at the point of junction.

The depth of the trenches should, as in all other cases, be sufficient to place the tiles beyond the reach of injury. It is not usually deemed necessary that they shall be made deeper than

this condition requires. In deep clayey soils, the depth frequently does not exceed 18 inches; and from 24 to 30 inches may be regarded as a suitable medium for soils of this kind. The trenches are made in the manner before described, by forming them with the common spade, and then employing the narrower spade, Fig. 113, so as to form the trenches at the bottom of the size just sufficient to receive the soles of the tiles. To render this system of draining efficient, a drain should be made in each water-furrow. Some make a drain only in each alternate water-furrow; but this, where the subsoil is tenacious, does not allow of the full efficiency of the system, and places the land next the undrained water-furrows in a less favourable situation, with respect to the escape of water, than the others.

This system of draining, from its opening numerous outlets, is of admirable use in rendering land dry. Small as the separate channels are for carrying off the water, they are yet generally sufficient to extend their effects over the half of each adjoining ridge with which they are in contact, and thus to produce a great degree of dryness at the surface; and by opening so many channels, the ground is rendered quickly dry after falls of rain, a point of great moment, as adding to the facility of tillage of stiff clayey soils. Further, the system is of easy execution, requiring little art on the part of the drainer. The use of tiles also simplifies the practice, and renders it of more general application. The tiles, although not so permanent as stones placed in deeper trenches, yet, when they are of good materials and laid with care, last for a long period, and when choked at any particular part by decay or subsidence, or by the accumulation of sediment, can be readily taken up at that part, and the tiles be replaced, or new ones substituted.

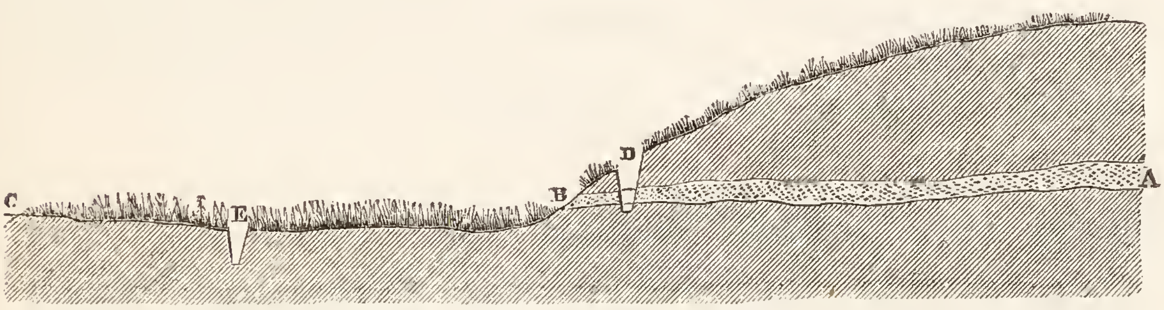
The modes of underground draining described are designed, it has been said, to make a sufficient number of outlets to afford egress to the excess of water in the ground; that to be now referred to, is more especially intended to reach the water at a greater depth, and carry it away before it shall reach the surface, or be imbibed in any way by the soil. The drains of the first

class, then, are designed to remedy the effect of wetness; those of the second, to remove the causes of it.

Water, it has been said, after it has sunk into the ground, tends to reach a lower level, by following those chinks and pervious seams in which it can percolate most freely. These seams are either nearly horizontal at the surface, or inclined; and sometimes they are of considerable extent, and sometimes they form a mere chink or crevice, coming to the surface at a single point, and forming a burst or spring.

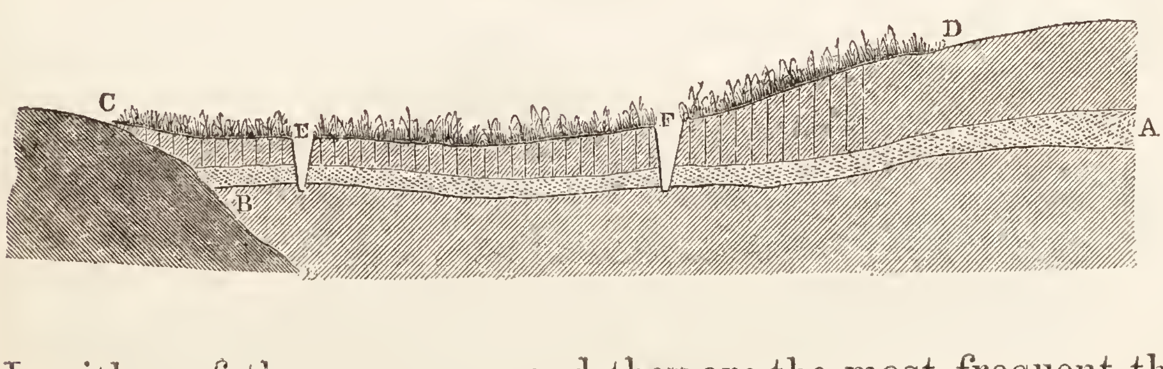
When any bed or seam of this kind, in which water is percolating, comes to the surface, the water which it contains will flow out, and form a burst or spring, as from B to C, in the following figure, which represents a section of the ground.

Fig. 122.



When water, in like manner, percolating through one of these pervious seams, meets any obstruction, as a rock or bed of clay at B, Fig. 123, it is stopped in its progress, and, by the pressure of the water from a higher source, is forced upwards, and thus saturates the superjacent soil from C to D, forming springs, or a general oozing.

Fig. 123.



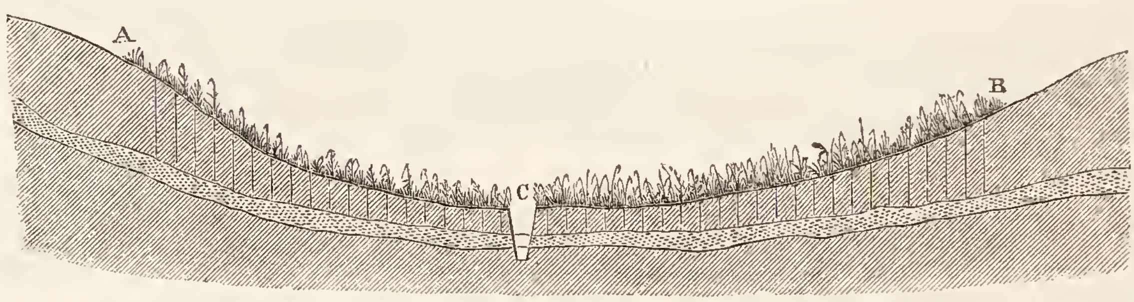
In either of these cases,—and they are the most frequent that occur in practice,—the design of the drainer is to reach the water

in its subterraneous channel, before it shall arrive at the surface, and to carry it away in a drain.

By cutting a drain across the ground, as at D, Fig. 122, the water of the pervious stratum BA, will be cut off before it reaches the surface at B, where it forms the swamp BC. And in like manner, by forming a drain at E or F, Fig. 123, the water will be cut off in its channel AB; and thus, in relieving the pressure from the higher source, by giving egress to the water through the drain, the cause of the wetness from D to C will be removed.

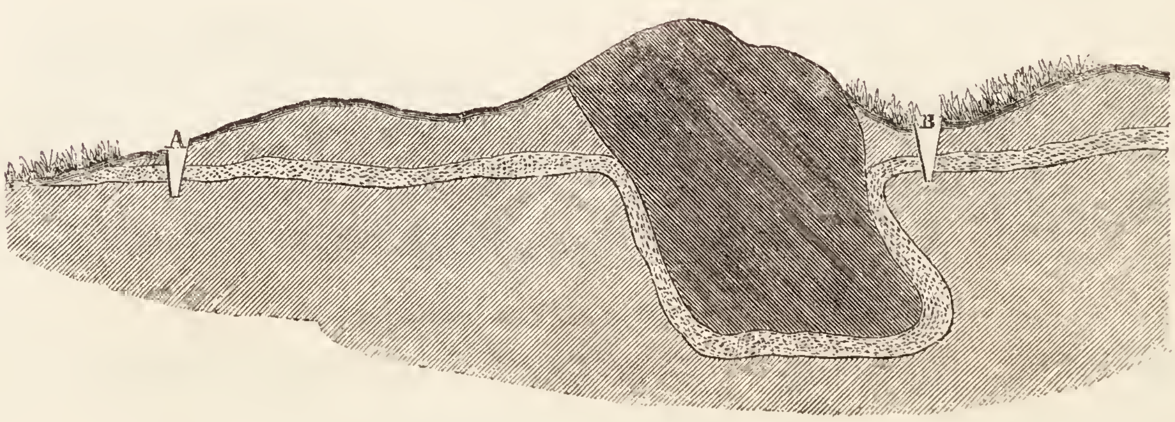
Sometimes, in a hollow tract of ground, seams may reach the hollow in the manner shewn in Fig. 124, and the water may be forced upwards by the pressure from each side of the hollow, and thus form the swamp from A to B. It may not be necessary here to cut a trench on each side, as at A and B, to reach the seam; and a single trench C, cut along the hollow, and giving egress to the water, will relieve the pressure, and remove the swamp.

Fig. 124.



Sometimes upon a sloping surface, a pervious stratum may produce more than one line of springs or swamps, as at B and A in the following figure. Here a single drain, cut across the swamp

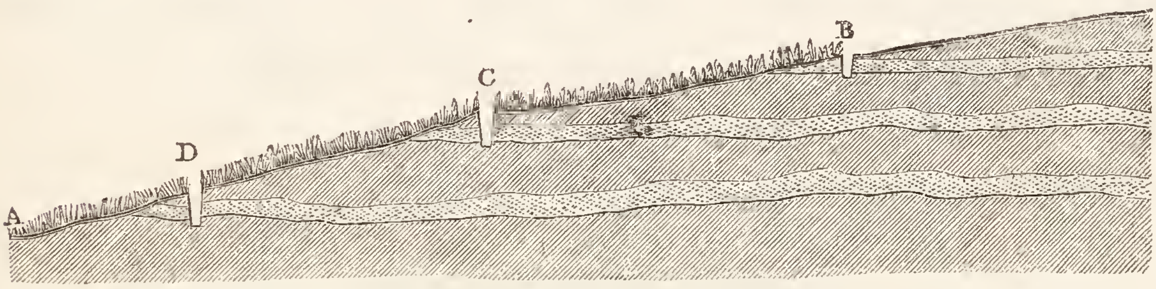
Fig. 125.



at B, will remove the cause of wetness of both swamps, without the necessity of a drain at A. Hence it is frequently seen that a drain cut across a swamp in the higher ground, will not only remove the water of the swamp, but often that of a number of swamps farther down the slope. Instances have been known, in which the interception of the water of a swamp on high ground has dried up wells and springs at the distance of half a mile or a mile.

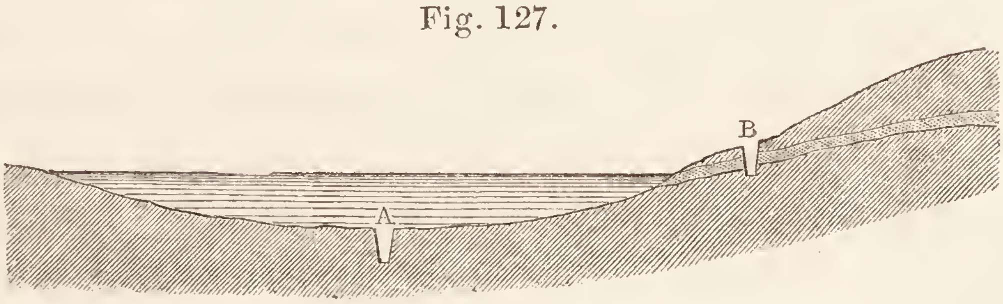
On the other hand, a single swamp, as from B to A, in the following figure, may be produced, and yet one drain, cut across ths line of descent at B, may be insufficient to remove the swamp. In this case, the water being brought to the surface in more than one seam, it may be necessary to form several drains across the ground, so as to reach the different beds in which the water is contained, as at B, C, and D. This, too, is a case, in which a single trench run in the line of ascent from A to B, might intersect the several seams.

Fig. 126.



In certain cases, water from the higher ground may reach, by its subterraneous channels, a basin-shaped tract of ground, as in the following figure, forming a morass. In this case, a trench, A, must be cut in some direction along the lowest part of the morass, in such a manner as to carry off the water in the hollow. But it may be necessary, likewise, to intercept, by means of a deep trench along the higher part of the morass, as at B, the water which is reaching it from the higher ground.

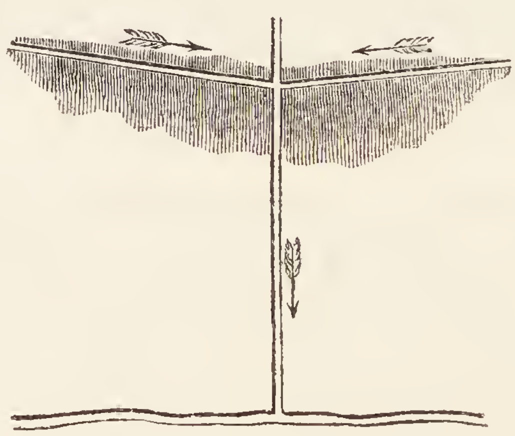
Fig. 127.



In these and similar cases, the end of the drainer is to reach the water in its subterraneous channels, and he must endeavour to effect this purpose by the most efficient and economical means. Every drain, however rudely devised and imperfectly executed, will be of more or less benefit, as affording an outlet to the water under ground; and it is easy so to multiply drains as to render any piece of ground dry. But one drain well laid out will perform a purpose which scarcely any multiplication of minor and insufficient drains can effect, and the skill of the drainer is shewn by his accomplishing his end with the least expenditure.

When a swamp or bursting out of water appears in any piece of ground, it may often be removed by running a trench in a direct line up and down quite through the swamp as in the following figure. Should this be insufficient, then branch or lateral lines are to be carried along the upper line of the swamp, at or a little above the line of wetness. The end proposed here is to intercept the underground water which forms the swamp, and if we shall succeed in reaching the pervious seam or seams in which the water is contained, we shall remove the wetness.

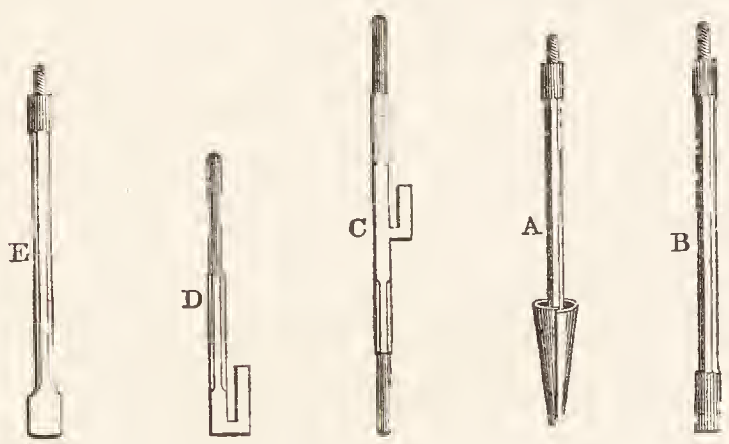
Fig. 128.



But the seams in which the principal body of water percolates may be too deep to be reached by a drain of common depth. In this case, apertures may be formed at the bottom of the drain, by boring or sinking down until the pervious beds in which the water is contained are reached. By this mean the water will be allowed to flow up from below into the cavity of the drain, and so will be carried away.

The application of this principle had been long familiar in the sinking of wells, but it was not until after the middle of last century that the same principle was applied to the draining of land. This was done by Mr Elkington of Warwickshire, who employed the auger and the boring-rod for the purpose of reaching the channels and reservoirs below the surface, when the ordinary drains did not reach them. The auger employed for this purpose is similar to a carpenter's wimble. Square iron rods are made to be screwed into one another, so that the length of the line of rods may be increased in proportion as the auger penetrates into the ground. In the annexed figure, A is the auger, B one of the rods, C a key for turning it round and working it, D another key for holding the rods when they are to be unscrewed by means of the key C, E a chisel or jumper for boring through rock.

Fig. 129.

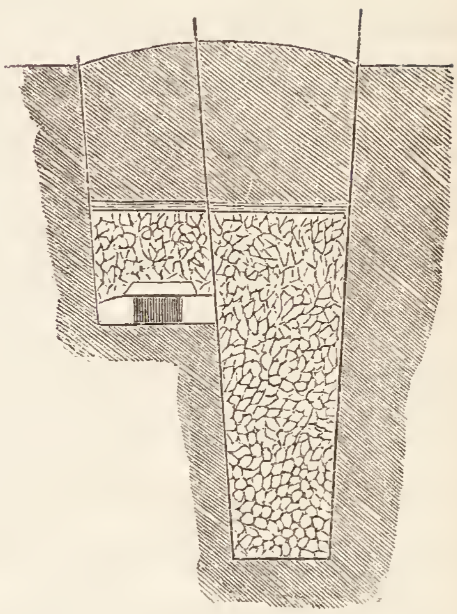


The apertures are formed by the auger in the bottom of the drain; and when the water is reached, it flows up into the drain in the same manner as water at the bottom of a well. It is not necessary to employ any artificial means for keeping the apertures open, as the flow of water will generally suffice to retain for itself a passage.

Sometimes, in place of an auger-hole, wells are sunk at intervals along the side of the drain, and filled with stones, in the manner shewn in the following figure.

If we shall look at the sloping surface of any tract of ground as a field, in which there is an oozing or bursting out of water, we shall generally distinguish the line where the wetness be-

Fig. 130.

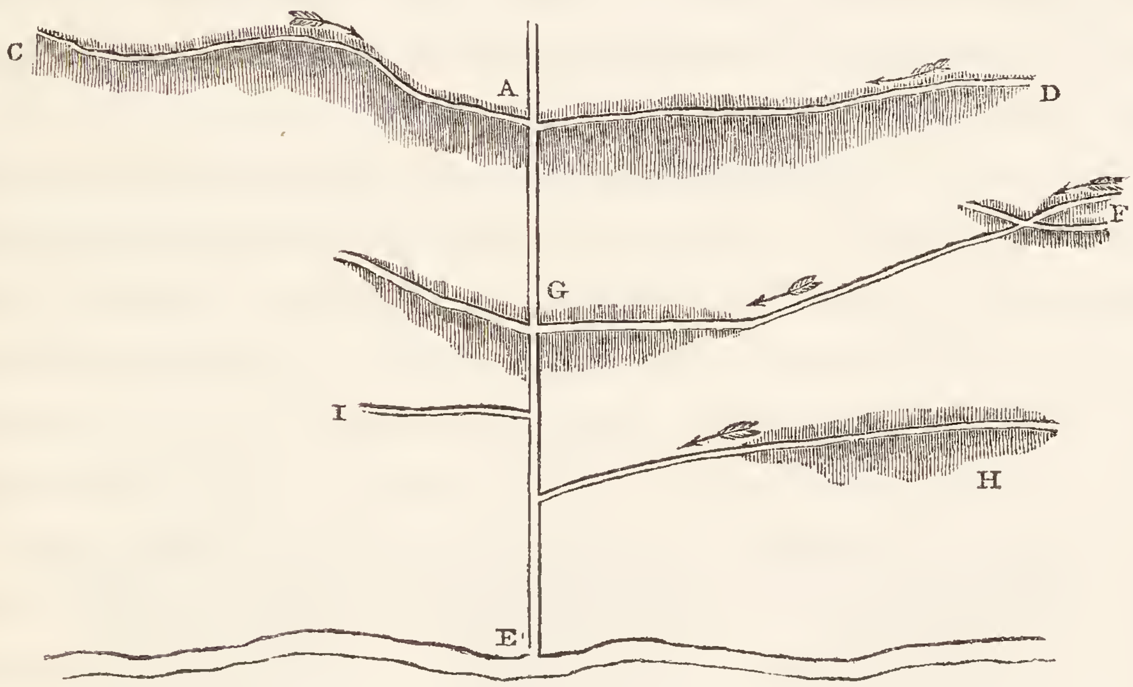


gins to appear on the surface, which is rendered perceptible by the colour of the soil, by the tendency to produce subaquatic plants, and by other indications of the presence of underground water. The wet portions of the ground are best discovered in the months of spring, when the parts which are surcharged with water will be readily distinguished from those which are comparatively dry. Now, in all cases in which the ground to be drained has either continuous lines of springs or detached swamps on the surface, we must run one deep trench at least, from the lower ground, quite up through the seat of wetness. This trench may be gradually deepened from the outlet at the lower ground to the parts where the indications of wetness present themselves, until it shall be 5, 6, or 7 feet deep, if necessary; and if we fail in reaching the pervious seams, we may employ the auger or well. A trench run in this manner will frequently be found to drain a great extent of wet land, whether the wetness appears in continuous springs or in detached swamps; the reason of which is, that the trench, intercepting the seams of pervious matter, affords an outlet to the pent up water. This trench, however, may not be sufficient to remove all the bursts or swamps in the ground to be drained. We are therefore either to form more trenches from the general outlet through other parts of the seats of wetness, or lateral branches from these trenches to the higher parts of the different springs or swamps.

Thus, in the following figure, in which C A D represents a line of springs, and F, G, H, I, detached swamps, let a trench E A be run from the outlet quite through the line of springs C A D. This trench may perhaps be sufficient to remove the wetness, in whole or in part, of the line of springs C A D; but if not, let lateral trenches be formed from A to C and from A to D as nearly as possible, at or a little above the line of wetness, or, in the language of farmers, between the wet and the dry, and sufficiently deep

to reach the seam or seams in which the principal mass of water is contained. These trenches may not reach the pervious seams at all points, but they may do so at a sufficient number to give egress to the pent up water. These trenches may also remove the swamps F, G, H, I. Should they not do so, let trenches in like manner be carried from A E to the upper line of the several swamps.

Fig. 131.



As the main drains may frequently cut off a long continuous line of springs and numerous detached swamps, it is well, in this species of draining, not to confine ourselves at first to the draining of detached fields, but to endeavour to reach the principal seats of wetness, previous to draining the several fields in succession.

Before beginning to drain a field or tract of ground, it is a common practice of professional drainers to dig pits in certain parts between the wet and the dry, for the purpose of ascertaining the depths of the seams, and the nature of the ground. The place of each pit is marked out 6 feet long by 3 wide, in which space one man, and if necessary two, can work. The earth is thrown out to the lower side to such a distance as that it may not press upon and break down the sides of the pit. The workmen continue to dig to the depth of 6 feet or more, so that the porous

beds may, if possible, be reached. When no water is found, then the boring-rod may be applied, in order to ascertain at what depth the porous substance lies in which the water is contained. Sometimes it may be so deep that it cannot be reached by any drain, in which case this preliminary examination saves the labour of making the drains unnecessarily deep. But the forming of pits in this manner is rarely required, and every purpose of a preliminary examination of the ground will be served by means of the leading up and down drains. These will, in all cases, be useful as outlets, whether or not they completely fulfil the end for which they were designed.

The system of draining infers, that the trenches shall be made of sufficient capacity. The depth should never be less than 4 feet, even when the pervious strata lie at a less depth; and the reason is, that the drains may be rendered more permanent, and be better defended from the mud and sand carried down by surface-water. It is not necessary that they should be made deeper than 4 feet, when this suffices to reach the seams; but they must be carried, if required, to the depth of 6 feet or more, notwithstanding that the expense and difficulty of the work increase in a great proportion as the size of the drain increases. The width need be no more than is sufficient to enable the workmen to work with freedom and safety. A drain of 6 feet deep may be 18 inches wide at bottom, and from 2 to 2½ feet wide at top.

The materials employed for filling may be stones, or, in case they cannot be obtained, tiles may be used. But where tiles are the material, a quantity of gravel or sand must always be laid above the tiles, otherwise the drain will be inefficient.

When stones are the materials employed, they should be laid down for use before the digging of the drain is begun. They are to be laid along the upper line of the drain, the earth being thrown by the workmen to the lower side; but sometimes they are brought forward while the work is going on, when they are thrown or shovelled out of the cart; and sometimes the carts are backed and emptied into the drain, although, in this latter case, the sides are apt to be injured.

In these larger drains, it is always proper to form a conduit at the bottom, either by the little walls of stone before described, or by means of tiles placed upon their soles. When the conduit is formed, and the materials thrown into the trench, the earth which had been taken out is shovelled upon the stones, care being taken, by means of a layer of sods or other substances, to prevent the loose earth from falling into the interstices. The spade or shovel is first employed for returning the earth to the trench, but sometimes for economy, the last portions are put in by the plough. A drain thus formed and filled with stones, will appear at first in a transverse section as in Fig. 132; and after the subsidence of the earth, as in Fig. 133. When tiles are the materials employed, the drain will appear as in Fig. 134, the trench in this case being narrowed at the bottom to nearly the size of the sole.

Fig. 132.

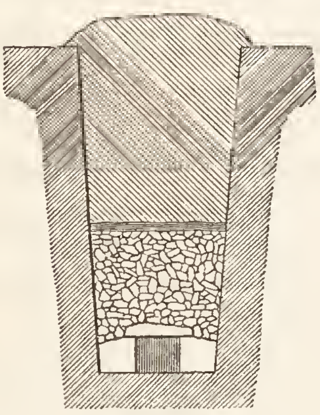


Fig. 133.

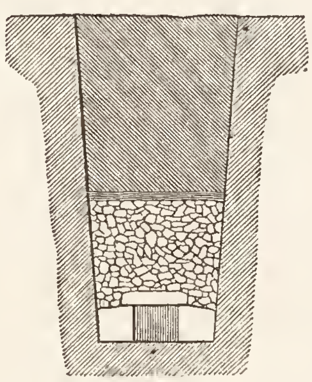
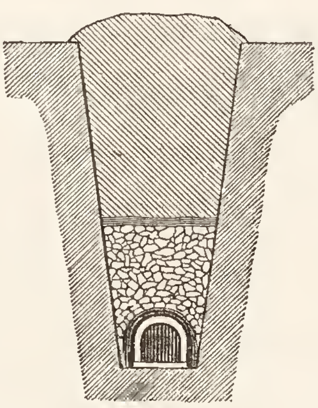


Fig. 134.



In the case of all drains, it is better that the trench be completed before the materials are thrown in, and that the filling of the materials shall proceed from the higher part of the drain to the lower. But in the case of very deep drains, as those of 5 or 6 feet, this cannot be done, on account of the hazard of the sides falling down. It is therefore necessary, that the forming of the conduit, and the filling of the drains, shall proceed nearly *pari passu* with the forming of the trench, care being taken, by means of bunches of straw, to prevent mud from being carried amongst the stones. One of the greatest difficulties to be overcome, is when quicksands are encountered. In such a case, it is often necessary to keep the earth from falling by placing planks at the

sides, and supporting them by stays;—and further, in the case of quicksands, either the bottom should be paved, or a box of wood substituted for the ordinary conduit. In the whole operations of forming the trenches and conduits of these deep drains, the utmost care is necessary in seeing that all the operations are performed well, and when they have been completed, care must be taken that they are not injured by mud being carried into them by holes on the surface, or by the principal outlets being filled up. The latter may be defended by iron gratings, to prevent the entrance of the larger animals, as badgers and foxes.

This system of draining is adapted, beyond any other that has been practised, for the removal of springs, swamps, and the larger runs of water under ground. But it is not always calculated to give that higher degree of dryness to land, and especially the stiffer clays, which the advancing state of agriculture requires. In this case it is required to form so many outlets that they shall be sufficient to *draw*, to use the technical term, over the whole ground to be drained. This is what is really meant by thorough-draining, and which may be effected either by small drains in the furrows, in the manner before described, or by such other arrangement of trenches as shall be found most suitable. The advantages of this kind of draining are very great, and it is calculated to give a highly increased fertility to a great part of the soils of this country, especially the stiffer clays. It is painful, however, to see the imperfect manner in which it is too generally practised. In the merely flat clay districts, less fault is to be found, because there is less choice of means, but in other cases, the drains are formed of insufficient depth, and without the necessary precautions to ensure their permanency. Hundreds of miles of these ill-constructed drains are already inefficient in every part of the country, or will shortly become so.

* A more detailed account of the principles and practice of draining, is contained in the Author's treatise " On Landed Property, and the Economy of Estates."

VI. SUCCESSION OF CROPS.

Plants, in so far as they derive their nutrient principles from the earth, must, in growing, exhaust the soil of these principles. When, accordingly, successive crops of herbaceous plants are cultivated on the same ground, and the produce is carried away, the soil becomes less fitted to nourish succeeding races of plants, or, in the language of farmers, is exhausted.

But when the produce is not carried away, but is returned to the ground from which it had been taken, the soil is not necessarily exhausted of nutrient principles. Thus, if a crop of plants, when growing, is covered by the plough, the soil is not impoverished, but is enriched by the matter mixed with it; and this is a method of manuring land which is practised in several countries, and which has been derived from early times.

In like manner, when land is allowed to produce the grasses and other herbage plants, and the produce is consumed by animals which leave their excrements upon the surface, the growth of the plants does not impoverish the soil. On the contrary, the consumption, or decay, of the stems, leaves, and other parts of the plants, enriches the soil, returning to it those earthy, alkaline, and other principles which they had derived from it, and adding to it those matters of organic origin which form one of the elements of its fertility. The laying down of cultivated land to grass, is accordingly one of the means employed by farmers to maintain, or increase, its powers of production.

Sometimes the process of decay of vegetable matters is counteracted by chemical changes which cause them to resist decomposition, as in the case of peat; but, with this exception, the effect of the decay of vegetables upon the surface is to add to the fertilizing matters of the soil.

But in the practice of the farm, the cultivated produce is, for the most part, carried away, in whole or in part, from the ground

on which it had grown. In such a case, the soil is always impoverished by the production of this crop, whatever the species of plants may be.

Yet all kinds of plants do not imbibe from the soil a like proportion of the same earthy, alkaline, and other constituents. Hence one kind of plants exhaust the soil of certain principles more than another. Cruciferous and leguminous plants deprive it more of its sulphates than the gramineous plants, and the latter, again, deprive it more of its silicates. The great red clover, *Trifolium pratense*, requires a large proportion of sulphate of lime. If this crop, accordingly, is repeated too frequently, or at too short intervals, it frequently ceases to grow altogether, unless the sulphate is either applied directly, or in sufficient quantity in the common manures of the farm. Certain maritime plants require a supply of common salt. These plants take up the salt largely by their roots, and grow feebly in proportion as the quantity of it in the soil diminishes by the continued production and removal of the same species of plants, and at length they cease to grow altogether when the salt is exhausted. Thus, though all plants exhaust the soil in growing, they do so in different degrees with respect to the substances taken up by them; and hence one species or family impoverishes the soil more with respect to the subsequent production of its own species, than with respect to other and dissimilar ones.

And not only do different species exhaust the soil in a different manner and degree, but the same species does so in a different degree, according to the time for which the plant shall be permitted to continue its growth. If plants are removed when young, they necessarily derive less of nutriment, whether mineral or organic, from the earth, than when they have arrived at maturity, and perfected their various organs. Thus, when leguminous forage plants, as the tare, are consumed in their young and green state for the food of animals, they are found to impoverish the soil greatly less than when they are suffered to arrive at their full growth, and ripen their fruits. The flax is what is termed by farmers a scourging crop; but it is found to be greatly less so if

removed in a green state, than if suffered to complete the period of its vegetation. Certain plants of the Brassica or cabbage genus illustrate the same law. Of this genus is the common turnip, which is usually sown in the early part of summer. In the first year, it forms a large napiform root, and puts forth an extended system of leaves. This is the first period of its growth, and if the plant is then removed, it exhausts the soil in a moderate degree. In the following spring, however, it shoots forth a flower-stalk, and bears seeds, which are ripened by midsummer. If the plant is suffered to arrive at this stage, it is found by experience to be one of the most exhausting crops which we usually cultivate: and the same remark applies to other plants, the carrot, the parsnep, and the beet, which, like the turnip, have two periods of growth, the one, that of forming their roots and leaves, the other that of shooting forth their flowering stems, and bearing fruits and seeds.

All plants, then, exhaust the soil in growing, and render it less fitted for the production of succeeding races of plants, but in a different degree for plants of their own species than for dissimilar species, and in a different degree, according to the period of their growth at which they are removed from the ground.

Nor is the effect confined to herbaceous or soft plants whose stems yearly decay, but it extends to shrubby plants and trees. When a forest is felled, or decays from age, it is rarely found beneficial to replant it with the same species of trees. The gardener who removes a fruit-tree, as a peach-tree, never replaces it by a peach, but by an apple, a pear, or some other dissimilar species. When a thorn hedge has decayed from neglect or age, it is never found beneficial to replace it by the same species of plants: thus the hawthorn is supplanted by the crab or the sloe, or better still, by plants of some entirely different family, as the beech, the birch, or the holly.

From the earliest times, the experience of husbandmen has shewn, that the same species of plants can rarely be profitably cultivated in continued succession on the same ground. If a crop of wheat is followed by another crop of wheat, and this by an-

other, it is almost always found that each succeeding crop tends to decrease with respect to vigour of growth and produce. But if the first crop of wheat is succeeded by one of beans, and this by one of oats or barley, the whole may be expected to grow without sensible degeneracy, and the soil to be no further impoverished than what it must be by having its produce removed. Hence, by changing the species of plants cultivated on any given space of land, a greater number of crops may be taken in succession than when one species only is produced.

Further, in the case of the herbaceous plants cultivated by the farmer, it is found that certain soils admit of a more frequent repetition of particular crops than others: thus, clayey soils abounding in alkaline salts, admit of the more frequent recurrence of wheat than the siliceous. Some plants, too, may be cultivated for a longer period in succession than others, and may recur more frequently without injury, whatever be the kind of soil. Thus, oats may be cultivated for a considerable time in succession without sensible degeneracy, provided the land is kept sufficiently fertile by the common manures of the farm, and so also may rice, if it is supplied with water. Hemp may be cultivated year after year, provided merely a sufficient supply of putrescent manures is given. The same is true of the Jerusalem artichoke, or tuberous-rooted sunflower in the fields, and of the onion and numerous plants in the garden. These cases do not invalidate the principle referred to. They merely shew that the ordinary manures of the farm supply the plants with the earthy, alkaline, and other constituents which they require; whereas, in the case of wheat and other plants, this source of supply is insufficient for the wants of the species.

Other circumstances are likewise to be taken into account as influencing the practice of the farmer in causing not one, but different species of herbaceous plants, to succeed to one another on the same ground.

Plants have a great difference in their habits of growth. Some have fibrous roots, which descend but a little way beneath the surface; such are all the gramina. Others have long descending fu-

siform roots, as lucerne and other leguminosæ. Such plants derive nourishment from a deeper portion of earth. Hence the two classes of plants are better calculated to grow in succession to one another, than species whose roots descend to an equal depth, and derive their nourishment from the same portions of soil.

Another circumstance to be regarded, is the difference in the modes of culture of plants. Some require a greater degree of pulverization of the soil, and this to a greater depth, than others; and this greater degree of tillage is given, otherwise the crops will not succeed. The turnip and other plants of the cabbage genus, the beet, the carrot, and the parsnep, admit of, and require, hoeing and other operations of tillage during a great part of their growth. Hence the benefit to such crops as the cereal grasses, the flax and others, which require, and in practice receive, comparatively little tillage, of alternating with crops which are necessarily more tilled and pulverized during their growth.

Certain species of plants, too, favour the growth of particular classes of weeds. The cereal grasses are found to favour greatly the production of other grasses, of which one is the creeping couch-grass, a weed universal in the fields of Europe. Flax is found to produce its peculiar weeds, and so likewise are the turnip and other cruciferæ, the carrot and other umbelliferæ. Hence the advantage, in the practice of the farm, of an alternation of crops, by which that multiplication of particular weeds is prevented, which accompanies the cultivation of a single species. And, as connected with the production of peculiar families of weeds by the cultivation of the same species, is to be mentioned the production of diseases. Certain parasitical plants attach themselves to particular species or families. Such are some of the fungi, which grow on the stems and seeds of the cereal grains, producing mildew, rust, or smut. It is found that the continued cultivation of the same or nearly allied species, tends to multiply those parasitic plants, and so to favour this destructive class of diseases. The effect is still more remarkable in the case of insects. Some are proper to peculiar species of plants, and when the crops are

not varied, it is often found that a destructive multiplication of these creatures take place.

This combination of effects may be held to explain satisfactorily the cause of the benefit of that alternation of crops which farmers adopt in their practice. More recently, however, another solution of the question has been proposed, and supported by the high authority of an illustrious physiologist.

It has been contended that plants excrete at the roots such matters as are not suited for the purposes of nutrition, in the same manner as animals excrete the matters which are not taken into the system. The excrements of the plants, it is said, are deposited in the soil, and as this is a matter which is noxious and unsuited to the nature of the plant which excretes it, its accumulation must be injurious to plants of the same kind. But it is not necessarily injurious to plants of another kind, to which, on the contrary, it may serve as a nourishment. Thus the excrementitious matter of the grasses, while it is noxious to the grasses, may afford matter of nutrition to cruciferous plants, as the turnip, or to umbelliferous plants, as the carrot and the parsnep.

To this theory, and the application which has been made of it, it is conceived that insuperable objections present themselves. That matters are excreted by the roots of plants must be admitted, but that this matter is more noxious to the plants that excrete it than to others, is not established by any satisfactory evidence.

The excretions referred to must consist of two distinct classes of substances: 1*st*, Those earthy, alkaline, or other bodies which have been derived from the soil, but which, not being fitted for the wants of the plant, are given back to the soil again. 2*d*, Those gummy, acid, or other substances, which are formed in the plant itself. With respect to the first class, it is evident, that it matters nothing with relation to the effect, whether they had never been taken up from the soil, or had been given back to it after being absorbed by the plant. In this respect, the theory is not opposed to the result of the hypothesis, that the substances had never been taken up from the soil, but it is manifestly defective

in this, that it makes no account of the principles that have been derived from the soil, and are retained by the plant, and which, in truth, are those only of which the soil can be said to be exhausted. With respect to the second class of substances, there is no proof that they are more injurious to the plants that excrete them than to others.

Many plants, as the grasses, are *social* plants, that is, they grow in company, and continue for an indefinite period upon the same ground. There is no reason to infer, therefore, that the excretions of the grasses are injurious to the grasses, or those of other social plants to their own species. The great nettle *Urtica dioïca*, is a weed which sometimes takes its place in pasture-fields, obstinately retaining its place, and covering a certain portion of ground. Why should this be so, if the excretions of the nettle were noxious to the nettle? But these patches of nettles, when they are cut frequently over, and the produce of them is removed, soon disappear. This is easy to be explained on the hypothesis that the nettle derives certain principles, as nitrate of potash, from the soil, the quantity of which is continually lessened by the carrying away of the plants, but is not explained by this theory of excretions, nor even reconcileable with it. Besides, these excretions being compounds of organic origin, must, like all such substances, be of easy decomposition, and soon give way to the influence of air or moisture. They may reasonably be supposed to be incapable of nourishing plants until they have begun to decompose, but this does not shew that they are less fitted to nourish the plants that excrete them than any other. If water, in which any kind of plants are grown, is employed to water the same species of plants growing in the soil, it will never be found that this water will be less beneficial to those plants than to any other.

But the theory of excretions of plants, though it is insufficient to explain the principle of a rotation of crops, is yet very deserving of attention in itself. These excretions certainly accumulate in the soil. After a crop of beans, the soil becomes dark in the colour, obviously from the accumulation of substances

derived from the plants. But these excretions are a mean of enriching the soil as soon as they have undergone decomposition. Hence the use of the summer-fallow, and of all methods of tillage, by which the soil is exposed to the action of the air.

But, whatever be the physiological causes assigned, the farmer is sufficiently instructed by the result, that, in order to cultivate his land successfully, and to economize his manures, and extend his course to the longest possible period, he must not cultivate the same or analogous species in continued succession upon the same ground. Having certain plants to raise, he is not to devote one portion of his ground to the continued production of the same species, but to cause that ground which has produced one kind of crop in one year, to produce another and dissimilar one in the following year, and so on, causing the different crops to succeed one another in a certain order all over the farm.

The kinds of plants to be cultivated in any case must depend upon two classes of considerations, 1*st*, The nature of the climate and soil; 2*d*, The demand which exists for particular kinds of produce. The first consideration depends on the physical circumstances of farms, the second involves questions of interest and profit.

The crops generally cultivated in this country on the large scale, may, with relation to their effects on the soil, and their place in the rotation, be divided into classes. They consist,—of the cereal grasses, cultivated especially for their seeds,—of certain leguminous plants, as the bean and the pea, cultivated likewise for their seeds,—of plants cultivated for the fibres of their bark, as flax and hemp,—of plants cultivated for their oils and other uses in the arts,—of plants cultivated for their roots, tubers, and leaves, as the turnip, the cabbage, and the potato,—of plants cultivated for forage and herbage.

1. Of the classes of plants enumerated, the most important with respect to the production of human food, are the cereal grasses. Those which are chiefly cultivated in the higher latitudes, are wheat, barley, oats, and rye. All the crops of these plants exhaust, in an eminent degree, the soil. They are all

suffered to mature their seeds, and therefore they are not removed from the soil, until they have derived from it all the principles, whether of mineral or organic origin, which the uses of the species require. And not only do these plants exhaust, in a high degree, the ground on which they have grown, but they exhaust the entire farm, because their seeds, an essential part of their produce, is for the most part carried away from the farm as the subject of commerce. Further, from the mode of culture applied to them, they receive only a partial tillage during their growth, and so tend to favour the production of weeds. Important, then, as this class of plants is, they can rarely be cultivated with advantage in continued succession to one another. They must alternate with species of other families, which derive other principles from the soil, which admit of a different degree of tillage, which favour the production of weeds less, and which, by their consumption, afford more of putrescent manures to the farm.

2. The leguminous plants cultivated for their ripened seeds, as the bean and the pea, resemble the cereal grasses in their effects upon the soil. They exhaust the ground upon which they have grown, and when their seeds are carried away to be elsewhere consumed, they exhaust the general farm.—But they differ from the cereal grasses in this, that they possess a broader system of leaves, better calculated to stifle the growth of stranger plants, and that they admit, especially the bean, of a superior degree of culture during their growth. And they differ from the cereal grasses, not only in their different habits of growth, but in their requiring for their support different earthy, alkaline, and other constituents, derived from the soil. The leguminous plants, therefore, may alternate with the cereal grasses, with less injury to the soil, and with a less demand on the putrescent manures of the farm ,than if the cereal grasses were cultivated in succession to one another. A leguminous crop, as the bean, may succeed a crop of any of the cereal grasses, and be again succeeded in the following season by another crop of cereal plants. There are, in in this case, three exhausting crops taken in succession, but the

intervening leguminous crop supplies itself with a different kind of food, and allows the ground to be more perfectly tilled, cleaned, and prepared for the crop which is to succeed. There are examples of land of great fertility, on which wheat and beans have followed one another in continued succession for a long period.

3. The plants chiefly cultivated for their fibres are hemp and flax. These plants, however, are of entirely distinct natural families, and exercise, accordingly, a different action upon the soil. While the hemp may be repeated almost every season, provided the land is largely manured, the flax can only be repeated at intervals, except in the cases of soils of extraordinary fertility. Both plants may be regarded as largely exhausting the manures of the farm. Their seeds, which themselves form one of the richest of vegetable manures, are usually carried away from the farm, while their stems are not useful for the food of animals, and add, accordingly, in an inconsiderable degree, to the manures of the farm.

4. Plants cultivated for their oils, and other uses in the arts, are so numerous and varied, that they cannot be reduced to any general law with respect to their effects on the soil and farm. It is the oleaginous plants that are chiefly cultivated on the large scale in the fields, and they may be generally described as exhausters, in an eminent degree, of the soil and farm. They are suffered to mature their seeds, which are carried away for the production of oil; and the stems, exhausted of their nutritive principles, yield little food to animals, and an inconsiderable return of manure to the farm.

5. The next class of plants to be referred to, is an important one with respect to the effects of the crops produced upon the soil and farm. These crops are sometimes termed *fallow-crops*, because a species of fallow is employed for preparing the ground for them; and sometimes they are termed *green* crops, because they are taken up and used in the green state. This class of crops consists of plants of the Brassica genus, the turnip, the cabbage, the rape, and others; of plants cultivated for their tubers, as the

potato and Jerusalem artichoke; of plants cultivated for their juicy fusiform roots, as the parsnep, the carrot, the beet. The crops of this class, from the modes of culture which they admit of, and require, are eminently conducive to the cleaning and pulverizing of the ground, to the eradication of weeds, and to the fitting of the soil for bearing an extended rotation of other crops. They require a large supply of manures, but the manure can be applied to them with greater benefit than at any other period of the course; for while a direct supply of putrescent manures frequently injures the gramineous and leguminous plants cultivated for their seeds, by causing them to produce straw rather than grain, it never injures the fallow-crops, in whatever quantity it is applied, while the abundant supply of the substance prepares the land for the subsequent crops which it has to produce. Further, those plants, when consumed upon the farm, add to its fertility by the large quantity of manure which the consumption of them affords. The fallow-crops, therefore, are at once cleaning and enriching, and afford one of the most important of the means at our command of maintaining or increasing the fertility of the farm.

But there are cases in which, from the state of the ground, and other causes, this class of crops cannot be raised. The resource, in this case, is to substitute the summer-fallow, which is equally or more efficient in the cleaning of the ground, and in producing the decomposition of organic matters in the soil. The summer-fallow, however, adds nothing directly in the form of manures to the farm, though it does so indirectly, by increasing the productiveness of the soil. The employment of the summer-fallow is also frequently connected with a more economical division of the labours of the farm throughout the season, and on this account is often beneficially substituted for fallow-crops. Whether in any case the summer-fallow, or a fallow-crop, is to be introduced into the rotation, a rule of good husbandry is, that one or other shall be adopted along with exhausting crops, and introduced at such intervals of time as shall be required for maintaining or improving the condition of the soil.

6. The last class of plants to be referred to consists of those

cultivated for forage and herbage. The plants cultivated for forage are mown and used in a green state for the food of animals. They either consist of a single species, as lucerne, sainfoin, vetch, or they consist of a mixture of several species, as the clovers and grasses. These plants being removed from the ground, when in a green and young state, they exhaust, though not excessively, the soil on which they grow, but when consumed upon the farm, they add to it a more than corresponding quantity of manure. They may, therefore, be termed ameliorating or enriching crops with respect to the entire farm, but exhausting with respect to the ground which produces them. If, therefore, repeated crops of this kind are taken from any piece of ground, the waste must be replaced by manures applied to the ground which produces them.

But often the crops of this class are made into hay. In this case they are suffered to form, and often to ripen, their seeds, and then they necessarily exhaust the soil more than if they had been consumed in their younger state. A hay-crop is therefore an exhausting one with respect to the ground that produces it, and if repeated crops of hay are taken, the waste must be supplied by manures; but a hay-crop does not exhaust the general farm, if all its produce is consumed upon it.

But plants of the kinds referred to, and especially that mixture of leguminous plants and grasses, usually termed the artificial or sown grasses, may be depastured, and thus consumed upon the place where they grow. In this case they do not exhaust either the soil which produces them, or the general farm. Land, therefore, bearing herbage plants is not in the condition of that which is producing crops whose produce is carried away. It is in a state rather of restoration than of exhaustion, and requires no manures to preserve it from deterioration or waste.

This is well understood in the practice of agriculturists. When the productive powers of a soil have been exhausted by cultivation and the carrying away of its produce from the surface, it is laid down to herbage, in which state the future vegetation which it produces, tends, by its decomposition upon the surface, to re-

store the productive powers of the soil. Land in this state is said to rest.

When land, however, has been impoverished by successive crops, and has become full of weeds, the laying it down to rest in that state is attended with less beneficial consequences than when the soil has been previously cleaned of injurious weeds, and fertilized by good culture. In the former case, the process of improvement is slow, if perceptible at all; the useless plants increasing, and not those which are beneficial and afford food to pasturing animals. Land, when properly laid down to grass, therefore, tends to recover its wasted powers of production. Land not properly laid down has less of this healing property, and may be more full of weeds, and little richer when ploughed up again after a time, than when first laid down. Under good management, however, the laying down of cultivated land to grass and other herbage plants to be consumed upon the ground, is a mean of resting the soil, and renovating its powers of production; and this mode of recruiting an exhausted soil being always at the command of the farmer, its application is important in practice. It is to be observed also, that the poorer soils require this species of rest and renovation more than those which are naturally productive.

Having the principles referred to in view, certain rules may be deduced from them for the order in which crops of plants may succeed one another on the same ground.

1*st*, Crops consisting of plants of the same or nearly allied species, shall not follow in succession, but shall return at as distant intervals as the case will allow.

2*d*, Crops consisting of plants whose modes of growth and cultivation favour the production of weeds, shall not follow in succession.

3*d*, Crops whose culture admits of, and requires, an efficient tillage of the ground, shall alternate with crops which admit of a more partial tillage, and the summer-fallow shall be substituted when such crops cannot be raised. And further, crops whose consumption returns to the soil a large quantity of manure, shall be

cultivated, when circumstances admit of their being raised, at intervals sufficient to maintain or increase the fertility of the farm.

And, 4*th*, When land is laid in grass, this shall be done when the land is fertile and clean.

Thus, in devising a rotation, we have to cause the restorative and cleaning crops so to alternate with the exhausting ones, as that the land shall be preserved in good condition; and when we find that land cannot be sufficiently cleaned or tilled by means of fallow-crops, we must make use of the summer-fallow. And again, when we find that land requires rest, we may lay it down to grass for a longer or shorter time, taking care, when this is done, that the land shall be in as fertile a state as circumstances have allowed, and free of weeds.

The shortest period for a rotation of crops is one of two years, as that in which beans and wheat are cultivated in continual succession to one another.

There are cases of land of extreme fertility, and where there is an unlimited command of extraneous manures, in which such a system may be, and has been, practised. But the example is one of a defective rotation. For there are two crops, each eminently exhausting to the soil and farm, cultivated in continued succession, and there is too frequent a repetition, at short intervals, of crops of the same species of plants, while there are no fallow-crops to economize manures, and maintain or increase the productiveness of the farm.

The shortest period for which an eligible rotation of crops can be devised, is one of four years, in which case the farm is in four divisions, on each of which is a crop of a different species of plants.

A course of four years is of very general application, and forms the basis of nearly all the most improved rotations on the lighter soils and inferior clays of this country.* It consists of a regular alternation of the following crops:—

1st year, Turnips, or other green crops, manured;

* Memoir by the Author on the Lease. Quarterly Journal of Agriculture.

2d year, Corn-crop, as wheat, barley, or oats;
3d Sown grasses, consisting of the usual mixture of leguminous and gramineous forage and herbage plants;
4th Corn-crop.

In this course, it will be observed, that each exhausting crop alternates with a restorative one, and that in each year one half of the farm is under exhausting and one half under restorative crops. Further, it will be observed, that when the corn crops are of different species, as when that of the second year is wheat or barley, and that of the fourth year oats, the same kind of cereal grain will only recur once in four years. This is generally a sufficient interval, even on soils of only moderate fertility; but even this interval is too short for certain species of plants, as the same course evinces. For, when the red clover forms one of the forage or herbage plants, it is found that, under a long continuance of the course, it falls off in productiveness, and at length can scarcely be made to grow. The land is said to *tire* of the crop, and the expression and the fact illustrate the general principle, that crops of the same kind should not recur at shorter intervals than their nature allows.

This rotation is adapted to a large class of soils fit for carrying green or fallow crops, although these soils ought to be rather of the better class, in order to admit of a long continuance of this course, in cases where there does not exist a supply of extraneous manures. When the whole produce of the green crops, and of the herbage and forage plants, and of the straw of the corn crops, is consumed upon the farm, the fertility of the soil may be maintained for a considerable period under this course; but when these are partially carried away, a supply of extraneous manures is necessary, otherwise the course becomes what is termed a scourging one.

The four years' rotation is frequently termed the Norfolk course, and it is in a great degree from the general adoption of it, that the husbandry of that country has become so celebrated.

In place of the green-crop in the first year may be substituted the summer-fallow, and then the course becomes :—

1st year, Summer-fallow ;
2d Corn-crop ;
3d Sown grasses ;
4th Corn-crop.

The course, thus modified, is adapted to the stiff and humid clays, where turnips and other green crops cannot be profitably raised. The course is defective in this, that the summer-fallow is too frequently repeated ; and it has the same defect as the Norfolk course, with respect to the frequent return of the cultivated red clover.

Other rotations, founded upon these, are produced simply by prolonging the period for which the land sown with grass-seeds shall remain in grass. When the course is intended to be for five years, the land remains two years in grass, thus :—

1st year, Summer fallow, or green crop manured ;
2d Corn-crop ;
3d Sown grasses ;
4th Grass for pasture ;
5th Corn-crop, generally oats.

This excellent course is less severe than the four years' course, and, requiring less manure to maintain or increase the fertility of the soil, it is better adapted to all soils of inferior quality. It does not yield so great a gross produce as the four years' course, and therefore, where the soil or the command of manures admits of the latter, there is not any reason why it should not be preferred. But in other and dissimilar cases, the five years' course, as this is frequently termed, will be found to be preferable. Wherever, in this course, the soil is suited to the production of green crops, the first crop of the series should be of that kind. But when the land is not suited to the production of green crops, or when, from any cause, the summer-fallow is to be preferred, then the summer-fallow may supersede the green crop in the first year of the series.

Although the five years' course, which allows the land to remain two years in grass, is suited to soils pretty low in the scale of fertility, yet it is often necessary, when the soil is poor or exhausted by previous cropping, to allow it a longer rest; in which case, the land, instead of two, remains three or more years in grass.

The four and the five years' courses are suited, it has been said, to a great extent of land in this country. But the richer clays, as well as the lighter loams of the better class, admit of a more extended and varied range of cultivation; the particular plants to be produced being determined by demand for the produce, peculiarity of local situation, command of extraneous manures, and the like.

When this is the case, it is easy to extend the four years' course in a manner to comprehend the further plants to be produced, in which case the land must be manured more than once during the period of the rotation. Let it be supposed that the land is of the richer clays, and that it is suited to the summer-fallow, then the course may be:—

1st year,	Summer-fallow manured;
2d	Wheat;
3d	Sown grasses, generally for hay or green forage;
4th	Oats;
5th	Beans, manured;
6th	Barley or wheat.

This is a course deserving of imitation in all the cases suited to it, that is, where the soil is sufficiently clayey and rich, and does not require rest in pasture. Under this course, it will be seen that two-thirds of the farm are under exhausting crops, and that one-third is in summer-fallow and restorative crops.

A slight deviation can be made on this course without altering the principle of it, namely—

1st year,	Summer-fallow, manured;
2d	Wheat;
3d	Beans;
4th	Barley or wheat;

5th year, Sown grasses, generally for hay or green forage;
6th Oats.

But we can render this course less severe, by allowing the land in grass to remain two years in that state, when the course becomes—

1st year, Fallow;
2d Wheat;
3d Sown grasses;
4th Grass;
5th Oats;
6th Beans;
7th Barley or wheat.

In which case we have three-sevenths in restorative crops, and four-sevenths in exhausting crops. When the soil is light and fertile, as a sandy or gravelly loam, the summer-fallow of the last-mentioned courses may be dispensed with, and any kind of green crop substituted:

1st year, Green crop, as turnips, potatoes, or beet, manured;
2d Wheat or barley;
3d Sown grasses;
4th Oats;
5th Pease or beans, manured;
6th Barley or wheat.

Under this course, as before, two-thirds are exhausting crops, and one-third restorative crops. The course requires a good soil. It may be rendered less severe by allowing the land to remain two years in grass, in which case the course becomes—

1st year, Green crop, manured;
2d Wheat or Barley;
3d Sown grasses, for green forage or hay;
4th Grass for pasture;
5th Oats;
6th Beans or pease, manured;
7th Barley or wheat.

In this case we have three-sevenths in restorative crops, and

four-sevenths in exhausting crops; and if we shall make wheat only once in the rotation, this course will fulfil in an eminent degree this condition, that two crops of the same species shall return at as distant intervals as possible.

These several courses illustrate the principle of a good system of rotations, as applicable to the plants commonly cultivated in this country, and they are all capable of being reduced to practice upon the farm, with a due regard to economy or manures, and a regular extension of farm-labour throughout the season. They may serve as the basis of other courses, where plants not enumerated here are to be introduced into the rotation.

VII. CULTIVATION OF PLANTS.

1. Plants Cultivated for their Seeds.

(1.) *CEREAL GRASSES.*

Of the cereal grasses, the most commonly cultivated in this country are wheat, barley, oats, and, in a lesser degree, rye. These present certain common characters, and admit, to a considerable degree, of a similar mode of culture. Before, therefore, treating of the species, it will be well to consider those circumstances with respect to culture in which the kinds enumerated agree.

The seeds of these cereal grasses may be sown either previously to winter or in spring; wheat and rye are, for the most part, sown before winter; barley and oats generally in spring. They may be sown broadcast or in rows.

When they are sown broadcast, the operation may be performed either by the hand or by a sowing apparatus.

When they are sown by the hand, the grain is contained in a basket, or in a sheet slung over the right shoulder of the sower. This sheet he holds distended by his left hand, and uses the right in sowing. He walks, with a measured step, along the ridge, scattering the grain in a uniform manner across it. He passes twice along a ridge of from 15 to 18 feet, so that each cast is across half the ridge. The corn is placed in sacks in the field at convenient distances, and may be carried by an assistant to the sower in a straw-basket (Fig. 135).

Fig. 135.

Experience teaches the sower to regulate the quantity to the acre, and to scatter it equally upon the surface. An inexperienced sower scatters it unequally, and often with intervals of thinner sowing between the casts.

To render the execution of the work less dependent upon the

skill and attention of the sower, and to deposit the seeds with greater equality, the broadcast sowing machine (Fig. 34) may be employed. This machine is drawn by a horse, which walks in the water-furrow, and it is of size sufficient to sow the half of two adjoining ridges, or the space of one entire ridge, at a time.

When this machine is used, the grain is, as in the other cases, brought forward from the sacks in a basket, and emptied into the seed-box. By the revolution of the internal spindle with its wheels or brushes, the seeds fall through the apertures; these apertures being made to be enlarged or diminished, so as to allow the seeds to fall through in the quantity required.

Whether this machine or hand-labour be employed, the harrows are immediately to follow, giving the number of turns required lengthwise and across, until the seeds are sufficiently covered.

When the grain is to be sown in rows, the sowing-machine may move either lengthwise in the direction of the ridges or across. In the former case it is convenient that the machine be of a size to suit the ridges, so that it may complete each ridge at two turns. The distance between the rows may be 12 inches. The land, after the machine has passed over it, is to be slightly harrowed.

The advantages of drilling are chiefly in the case of the lighter soils, and especially where these are apt to be overrun with annual weeds. The intervals between the rows admit of being tilled by the hoe, so that annual weeds may be destroyed before the crop shall cover the ground. This tilling between the rows, too, is favourable to the growth of the plants. In Norfolk and the lighter soils of Suffolk, and indeed very extensively in England, the drill-system accordingly is preferred to the broadcast. In the north of England, and in Scotland, the broadcast system is preferred. When the land is sown broadcast, it admits of no farther tillage during the growth of the plant. For the most part, the only weeding which it receives is the pulling up of individual plants, but more frequently by cutting them over by the simple instrument termed a weed-hook.

Fig. 136.

Before the corn shoots, as in the month of June, bands of young persons, or females, with these weed-hooks, pass along the ridges, and cut over the thistles, docks, or large weeds; which is generally sufficient to prevent their rising to seed, and interrupting the reapers in harvest.

When the corn, however, is sown in rows, it admits of being hoed in spring. This is sometimes done by a horse-hoe. But the more general method is by the hand-hoe (Fig. 78). Each hoer generally takes one row, hoes the earth as near to the growing corn as possible, and pulls up also by the hand any weeds amongst the corn.

The cereal grasses receive no other tillage during their growth, except an incidental one when the grass-seeds are sown amongst them in spring. The grass-seeds are sown broadcast upon the surface, and then covered by the harrows or roller.

In the end of summer, when the green colour of the stem has nearly disappeared, and when the grain, having changed from its milky state, has somewhat hardened, it will be proper to commence the process of reaping. It will not be necessary to delay the operation until the grain shall have become what is termed dead-ripe; for before this state of the plant has occurred, the grain will have attained its maturity of size, and the sap have ceased to ascend to nourish it, and the process of hardening will proceed equally well, although the stem be separated from the ground. By cutting before the state of extreme ripeness, hazards from winds and rain will be lessened, as well as the loss from shaking out the grain during the reaping and removing of it; and the straw will be secured more full of nutritive juices, and more fit for the purpose of provender.

In the reaping of corn the stems should be cut as horizontally and close to the ground as the nature of the instruments employed will admit. They should be laid in rows or bunches, with

the heads in one direction, in such a state as to be easily collected and bound into sheaves, and all this with the least waste of grain and the greatest economy of labour.

The instruments employed in reaping are the sickle and the scythe. The blade of the sickle is smooth or serrated.

Fig. 137.

Fig. 138.

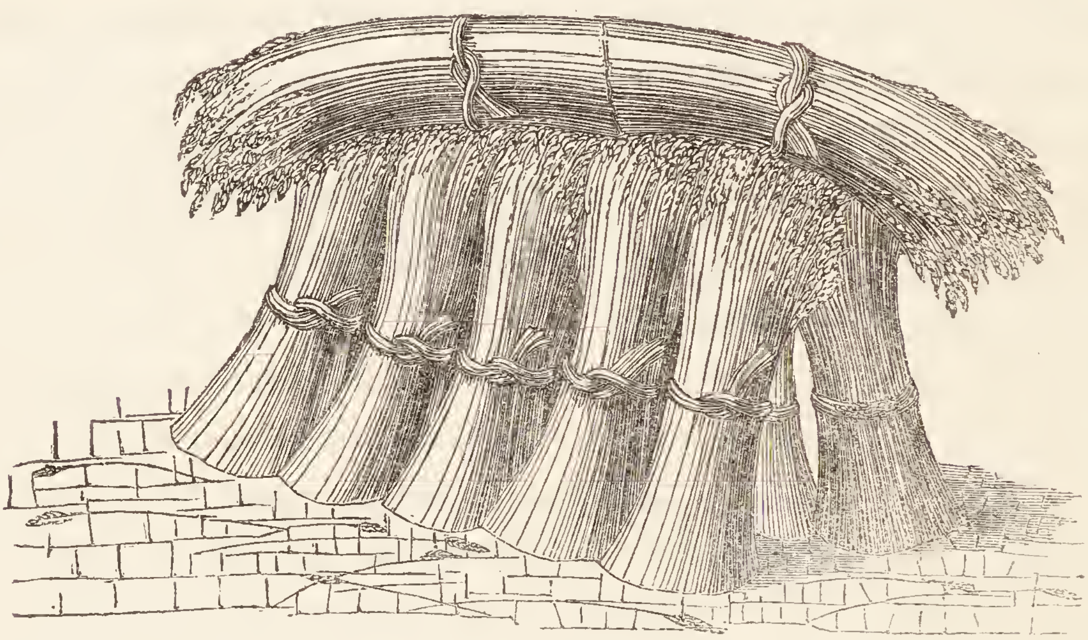
In using the sickle, the reaper holds the instrument in his right hand, and seizing the stems of corn by small portions with his left, he cuts them horizontally through within a few inches of the ground, by pulling the sickle towards him. When he has collected as much as he can conveniently support by his hand, he lifts the whole up by the aid of his sickle, and lays it on a short rope, formed of the stalks of corn, and laid upon the ridge behind him. When a sufficient number of these handfuls is laid upon the rope, another person who follows binds the whole up into a sheaf.

To arrange the reapers in the field in the way best suited for despatch, let 3 be placed upon each ridge when the breadth is less than 18 feet, with a man for every 6 reapers, to bind the sheaves, and place them upright in the way to be described. Let it be the duty of the central reaper of each ridge to make also the ropes or bands by cutting, or, when the corn is very short, by pulling a small handful of the corn, dividing it into two smaller parcels, and twisting them together at the ear-end; and let this band be laid down upon the stubble behind him. When the ridge, however, is 18 feet or more in breadth, there may be 4 reapers upon each ridge, and then there must be 2 binders for every three ridges, being one binder for every 6 reapers as before.

The binder, having tightly bound the sheaves, places them upon every alternate ridge, resting upon their bases, and upon one another. Five pairs of these sheaves, when the crop is oats or barley, and six pairs when it is wheat, may be conveniently placed in rows together; and in the case of the oats or barley, the whole may be covered by two sheaves, the but-ends of which lie towards each other, with the ear-ends divided a little, and

pulled down so as to cover and defend the upright sheaves, thus making twelve sheaves to each shock. In the case of wheat, the stems of which are hard and dry, and which requires to stand in the field only a few days before it is ready to be carried home, the head-sheaves are omitted. In the case of oats and barley, which, on account of the great softness of their stems, require to stand a longer time in the field, the head-sheaves are used for the purpose of securing the upright sheaves against the effects of the weather.

Fig. 139.



The shocks should be set nearly north and south, so as to be equally dried by the sun on both sides. By means of the head-sheaves, the other sheaves are protected from an ordinary shower, which runs off from the convex surface, and the whole stand till they are sufficiently dry to be transported to the barn-yard.

There is one variation from this method of arranging the sheaves to be noticed. It is ever proper to cut crops of corn when dry, but often, from the effects of dews and rains, the crop is in a moist state when it is necessary to reap it. In this state—and the observation applies mostly to oats—it might be unsafe to bind the sheaves tightly at once, lest they should become mouldy, or the ears sprout. In this case, the rope may be drawn very loosely round the sheaf, and nearer to the ears, so that the bottom may

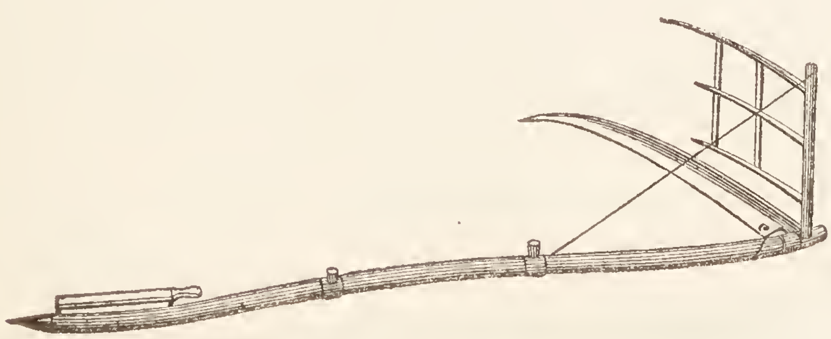
be stretched out, and each sheaf made to stand separately upon its own base (Fig. 140). In this state, the sheaf is less protected from the injuries of the weather, but a readier access being allowed to the air, it dries sooner, and is not so apt to be injured when it has been put up in a wet state. Before these loose sheaves are removed from the ground, they ought to be bound tightly together in the same manner as the others, and either carried at once to the barn-yard, or placed in regular shocks until it shall be convenient to remove them.

Fig. 140.

In this whole process of reaping, a very minute care is necessary in causing all the parts of the work to be well and diligently executed. It is especially important that the reapers be made to cut as low as can conveniently be done; for in this way only will the stubble be left clear of loose and straggling heads. Further, the straw of this class of plants is always more succulent near the root, and a slight difference in the height of cutting will make an essential one in the weight and value of the straw produced.

The other instruments usually employed in reaping, are scythes of different kinds. The common scythe may be employed for this purpose, in which case there should be attached to it an apparatus (Fig. 141), for the purpose of supporting the stem, during the action of the blade, and laying down the corn with regularity.

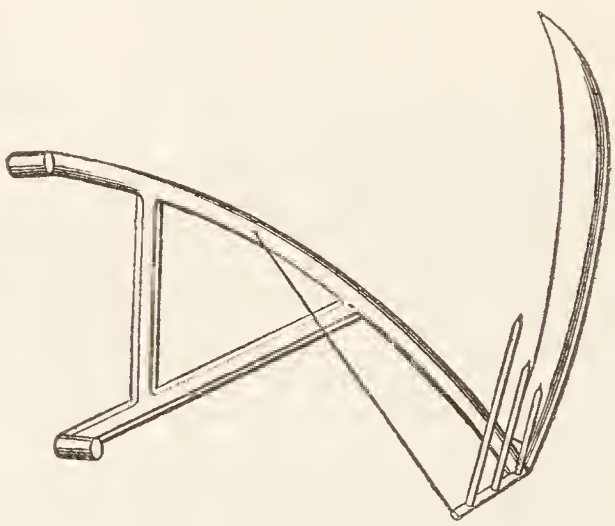
Fig. 141.



This apparatus, usually termed a *cradle*, may consist of three slightly bent pieces of ash, mortised into a piece of wood, which

is attached to the end of the lower part of the handle, so as to be vertical when the scythe is at work, and the upper part is fixed by a rod or cord passing from it to the handle. The three pieces of ash stand above the scythe, and parallel to it, and are of such a length as to extend over half the blade or more. In place of the common scythe here described, there has been recently introduced one with two handles, which, by placing the mower in a less constrained position, is more easily worked.

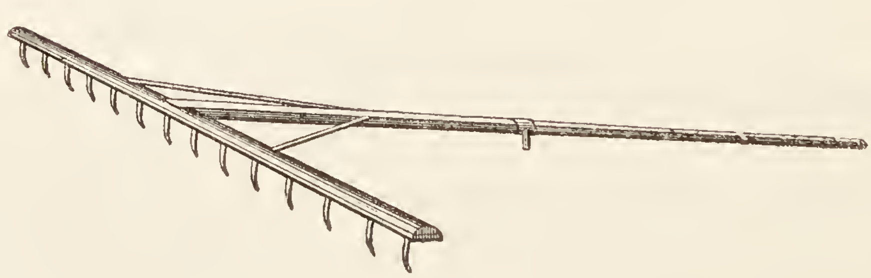
Fig. 142.



The mower cuts from right to left. In some parts the practice is, for the mower to cut towards the standing corn on which, accordingly, the cut corn rests, assistants following close to remove it. But the better practice is, for the mower to cut towards the open side. In this manner, the corn is laid down with considerable regularity.

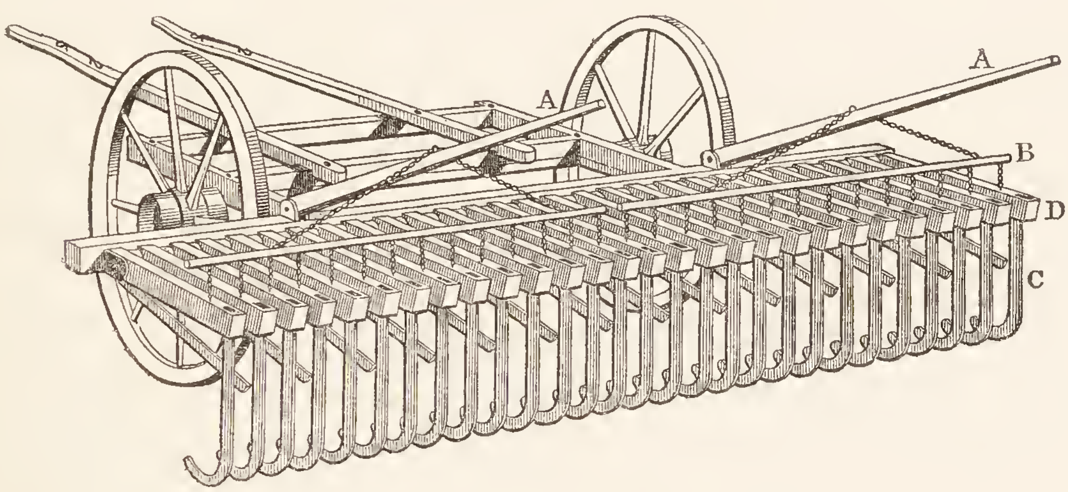
Each mower is followed by one person, to make the bands, and lay the corn upon them. A person follows immediately, and binds up the sheaves, precisely as is done in the case of reaping with the sickle. Another person follows every two mowers with a large rake, with curved iron teeth (Fig. 143), to rake the stubble.

Fig. 143.



In place of the hand-rake, rakes drawn by horses may be employed. The following is an example of one of this class of instruments, so formed that each tooth moves independently of the other. The teeth are of iron, fixed each to a separate handle of wood, and all the handles are attached by their extremities to a rod of iron, on which they are moveable. Further, the handles are all separately attached by chains to a common bar, and this bar being attached by chains to handles held by the workman, the whole teeth can be lifted from the ground at once, and the collected stems of corn allowed to fall down. In the figure, C is one of the teeth, D the handle to which it is fixed, B the common bar to which the handles of the teeth are attached by chains, AA the handles held by the workman, and attached by chains to the bar B. Further, the bar B may be divided into two parts, so that one-half of the teeth shall be raised at the same time.

Fig. 144.

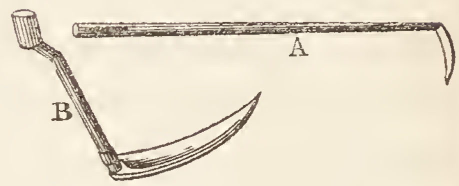


Corn mown by the scythe is cut closer to the ground than is common in practice by the sickle, and the stems being less compressed together, they are sooner ready for being carried home than when reaped by the sickle. The sickle excels the scythe in this, that the corn is laid down more regularly, and with the heads in one direction ; a point of importance in all cases, but especially when the thrashing-machine is to be used.

An instrument surpassing the sickle in despatch, and the scythe in the regularity with which it lays down the reaped corn, is the Hainault scythe (Fig. 145).

The workman holds in his left hand the bent instrument, A, with which he presses upon the corn about the middle, and he then strikes it near the root with the scythe B, which he holds in his right hand, laying the cut against the standing corn. He employs the bent instrument and the scythe to collect the corn. This method of reaping is practised in Flanders; and a similar method, though with a different instrument, is followed in some parts of England.

Fig. 145.



Whatever be the means employed to reap the corn, it ought not to be left loose upon the ground, but secured in sheaves and shocks until it can be transported from the field. This is required, at least in a moist and uncertain climate.

When the corn has remained a sufficient period in the field for the juices in the stem to be dried, and when the sheaves are freed from external moisture, it will be time to convey the crop from the field, and to secure it in a place of safety. A certain exhaustion of the natural juices is necessary; for otherwise the mass, when collected together in quantity, and excluded from the air, would ferment. While, therefore, no favourable occasion is to be neglected of securing the crop, its subsequent safety must not be endangered by precipitation. The proper time for its removal will be learned by a little practice in the fields. The sheaves should feel light when lifted up, and no particular sensation of cold or damp should be experienced on thrusting the hand into the body of them. In four or five days of good weather, wheat will generally be fit for carrying home, and oats and barley in twelve or fourteen. But the process may be retarded when the air is moist, and without wind, and still more when rains intervene. In this case, the ear will often sprout, and the straw become injured. Frequently, in these circumstances, the head-sheaves must be removed to give access to the air, and often the entire sheaf spread out during the intervals of sunshine.

The corn being ready, the sheaves are to be forked into the

cart or waggon. The cart employed is sparred at the sides, and has a projecting framework all around (Fig. 55). The sheaves are built on the carriage by the driver, another person forking them to him from the shocks. In building, he lays courses along each side, the but-ends outermost, filling up the heart by sheaves laid lengthwise. In this manner, he proceeds, until he has built the load to the height to which it can be with safety raised, when two ropes, one fastened to each side, are thrown over the load, and tied tightly at the opposite sides ; but when the distance is short, the tying with ropes is omitted.

The corn is then to be secured in stacks built near the barn,—a practice greatly superior to that of securing it in large houses or barns in a climate like that of Britain. When placed in this latter situation, the corn requires to remain longer in the fields before it can be safely stored, is more subject to injury from various causes, and, being too much excluded from the external air, does not keep so safely.

The stacks may be made circular, with a diameter of 12 feet or more, according to the convenience of the farmer, and the size of his barn. The manner of working is this :—

A circular layer of straw, or other substance, is laid, to form the bottom. The workman begins by placing a sheaf upright in the centre of the intended stack, round which he places other sheaves, also on their but-ends, with the tops inclining inwards; and this he continues to do in regular courses, the sheaves being placed closely together, until he nearly reaches the outside of his foundation. He then lays an outside layer all around, the buts being outwards, with the top, and upper half of the sheaves resting upon the inner ones. In this operation of laying the exterior layer, he first grasps a sheaf, and then, placing it close to, and somewhat upon, the sheaf last laid, he presses upon it with his hands and the weight of his body, and lifts himself forward, until he has placed his knees upon it : and then, grasping another sheaf, he in the same manner, places it in its position, and so moves on from sheaf to sheaf. He thus lays a layer of sheaves

all around, and sometimes a second layer, in the same manner, until he has raised the whole nearly to the same level as the top of the upright sheaves before mentioned.

Having completed this first part of his work, that is, having laid his outside layers, so that the whole may be nearly level, but with a slight dip from the centre outwards, he proceeds thus :—He lays his second course of sheaves all around, with their buts about 15 or 18 inches further back than those of the outside course. Having done this, he fills up the interior of the stack ; but in filling up the interior, he does not generally observe the same order of courses which he does in laying the courses ; he merely packs the sheaves in a proper manner, so that they may fill up the whole interstices. He now lays an outside layer all round with the buts outward, as before, and the ear-ends lightly elevated, by resting upon the buts of the last laid or inner course. Thus he proceeds, alternately laying the outside and the inner course, and filling, as he proceeds, the heart or interior, carefully preserving, as has been said, the dip of the sheaves from the centre outwards.

Sometimes when the stack is very large, or the straw short, more than two courses are laid. The process, however, is the same. The different courses overlap, and the workman proceeds by laying the courses in succession upon one another, and filling up the heart.

When the workman has carried his stack to the height of 10 feet, or more, he begins to contract it. But he first lays a course projecting a few inches beyond the outer course last laid. This is intended to form the eaves of the roof ; but often this is dispensed with, and is not essential.

After this he contracts the stack, each successive course of sheaves being laid more inwards. At the same time, the elevation of the centre is not only preserved, but increased, so that the sheaves may have an increased obliquity as the upper part of the stack is formed.

When the workman has contracted the top to a platform of three or four feet in diameter, he rises from the position in which

he has hitherto worked, and places a sheaf upright in the centre, and this he surrounds with sheaves standing in like manner upright, but with their tops inclining inwards, and leaning upon the centre sheaf. This summit of upright sheaves he firmly surrounds with two or three turns of a straw-rope, the ends of which are sometimes fixed to opposite sides of the stack, so as to prevent the summit from being blown down.

The stack is now in the form of a cylinder with a conical top. It is usual to make the diameter of the stack increase as it rises in height. This deviation from the perpendicular, however, should be very slight, as it tends to render the stack more apt to incline to one side.

The stack is now to be thatched, after it has subsided a little, and it is proper that a certain quantity of straw be in readiness for the purpose. The straw is formed into bunches, by drawing it out by the ends into handfuls: the short straw which is separated in this operation is reserved for other purposes, as forming the bottom of the stacks, and partly also for thatching.

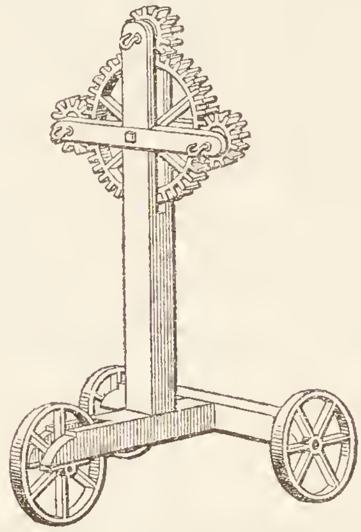
Twisted straw-ropes are to be in readiness. They may be made by means of the simple instrument, Fig. 146. It consists of a handle of from two to three feet long, bent at one end like a bow, and having at the other a ring and swivel, through which ring a straw-rope is passed, which is tied round the waste of the worker. The straw to be twisted is fixed to a notch at the end of the bow, and gradually supplied by a person from a heap. The other worker, who may be a very young person, the work requiring no exertion of force, walks backward, turning the bow round with one hand, until the rope is formed of the length required. The ropes thus formed are coiled upon the arm, and reserved for use.

Fig. 146.

In place of the instrument described, one may be employed, Fig. 147, to twist more than one rope at a time. It is formed upon the principle of the common rope-making machine. It is attached to the body of the workman, who walks backwards, turning the handle.

The workman who thatches the stack stands upon the roof. The bunches of straw being handed or forked to him, he spreads

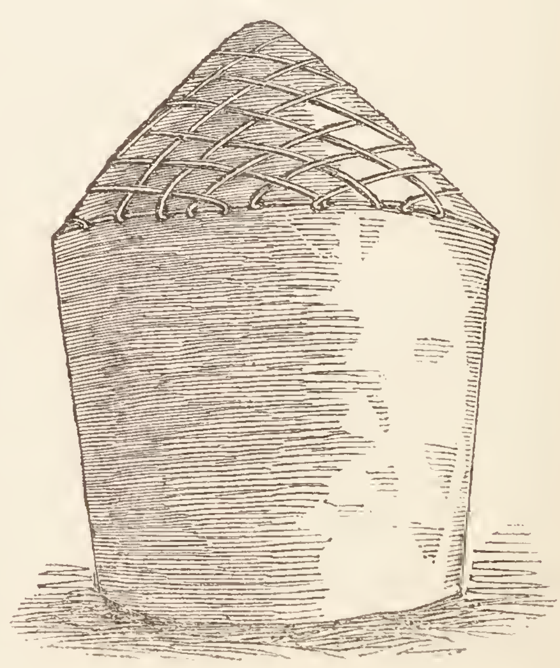
Fig. 147.



the straw in handfuls all around the stack, laying successive layers until he reaches the top, the higher overlapping a little the lower; and he takes care, by working backwards, not to tread upon the straw already spread. When he reaches the upright sheaves at the top, he lays on a thick row of covering, which may consist of short straw, which he draws to a point at the top, and makes tight with a thin straw-rope wound round it.

The straw is then fastened down by means of the straw-ropes already described. The thatcher stands upon a ladder aloft so as to be able to reach the summit, while two assistants remain on the ground below, or are supplied with short ladders. He lays the ropes over the roof in a series at the distance from one another of 12 or 15 inches. They are passed obliquely over the roof, and fixed to, or wound round, another rope placed above, or below, the eaves, as in the figure.

Fig. 148.



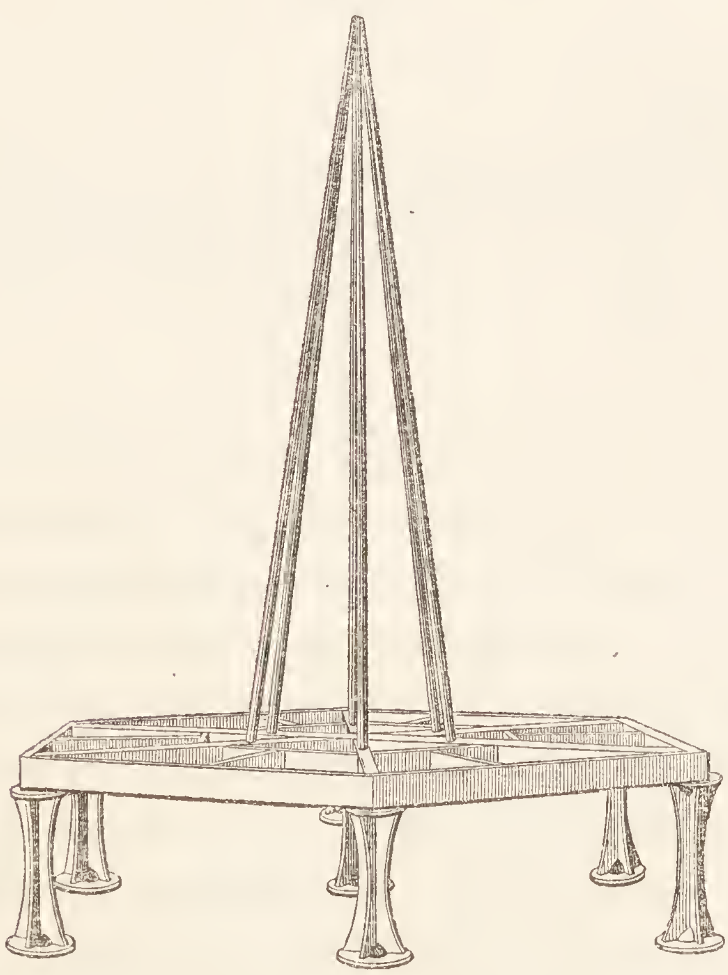
Considerable danger arises in wet seasons, if the corn is carried home in a damp state; but this may occur in any season, if the straw is not freed of its

natural juices before being carried from the field. The incipient fermentation is denoted by the great heat of the interior of the stack, which will be rendered sensible by thrusting in the shaft of a fork, and feeling it when it is withdrawn, or by pulling out a handful of corn, or by merely thrusting in the hand. If the heating proceeds so far as to threaten injury to the stack, the whole should be turned over and rebuilt, or carried to the barn and thrashed.

In wet seasons farmers are frequently obliged to form their stacks hollow in the centre, so as to allow the access of the air. This is done by placing upright posts fastened at the top, and stretched out like the legs of a theodolite, and building around them. An opening being made in this hollow from the exterior of the stack, a current of air is admitted.

Often stacks are placed on pillars of stone, or of cast-iron, as in the following figure:—

Fig. 149.



The building and thatching of the stack complete the harvest-

operations for the cereal grasses. The leguminous plants cultivated for seeds are secured in the same manner.

The stacks being secured, remain until it is convenient to thrash the corn and prepare it for use. The thrashing by the flail is a work of labour, and notwithstanding every care, a considerable part of the grain remains attached to the straw. Labour proceeds slowly at a time when despatch may be important, and the thrashed corn remaining generally for a considerable time in a heap is subject to injury of various kinds.

For these reasons, the invention of the thrashing-machine is to be regarded as important in the progress of improvement. The farmer, by means of it, is enabled to get his work performed at once and with despatch, and in a more perfect manner than is usually done by manual labour. It is in these things rather than in the saving of expense, that the superiority of the thrashing-machine over the flail consists.

The thrashing-machine has always a winnowing-machine attached, and forming a part of it, by which the grain is partially freed from the chaff and impurities. Sometimes two winnowing-machines are attached to the larger class of thrashing-machines; but this is rare, and where there is only one winnowing-machine, the corn, as it is received from the thrashing-machine, undergoes a further process of winnowing in a separate machine, in order to be fully cleaned.

The thrashing-machine performs three operations:—First, it beats the grain and chaff from the straw, by means of the beaters fixed upon its revolving cylinder; secondly, by means of its revolving rakes it shakes the chaff and intermingled seeds from the straw, which last is separately thrown out of the machine; and thirdly, by means of the attached winnowing-apparatus, the seeds are separated from the chaff, and being received from the machine, are carried away to undergo a final dressing in a separate winnowing-apparatus. The barn for these operations, it has been seen, is divided into three apartments:—First, that in which the unthrashed corn is put; second, that immediately underneath it, in which the corn is received from the thrashing-machine, and

afterwards winnowed; and third, that into which the straw falls from the thrashing-machine, and where it is generally stored for use. This last is termed the straw-barn, and ought to be of a size sufficient to contain the produce of two stacks.

The first operation to be performed in thrashing is to carry the unthrashed corn from the barn-yard to the barn. A piece of canvass is laid at the side of the stacks for the sheaves to fall upon. The sheaves may be carried to the barn by two persons, on a piece of canvass fixed on two poles (Fig. 150); or they may be conveniently carried on light sparred barrows (Fig. 151).

Fig. 150.

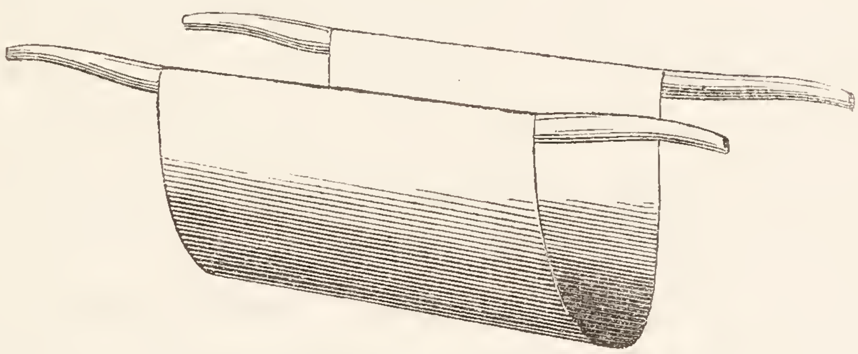
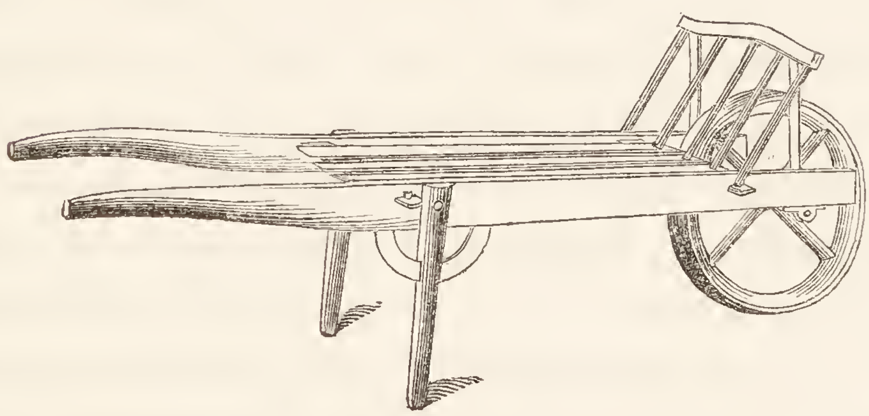


Fig. 151.



When the machine is put in motion, one person is employed to carry forward the sheaves, another to lift and lay them sheaf by sheaf upon a table adjoining the feeding-board. The duty of the person who lays the sheaves on the table, is to loosen them, untwisting at the same time the bands, and laying them in the direction of the sheaves. The person who stands at the feeding-board takes the unthrashed corn from the table, and spreads it upon the board, pressing it forwards towards the fluted rollers. His duty is to convey it in due quantity to the machine; and generally, to observe that all is right with regard to the machinery.

Two persons, generally females, are employed in the dressing-barn, to convey away the grain as it comes from the thrashing-machine. Two are employed in the straw-barn, one to take away the straw as it falls from the machine, and to pile it up in the straw-barn, and another to build and tread it; and, where animal power is employed, one person drives the working cattle.

The taking away of the grain from the machine is carried on continually by the two assistants in the dressing-barn, in riddles (Figs. 152 and 153).

The winnowing machine, from the description formerly given of it, will be seen to separate the corn into three parts,—first, the chaff, which is blown away—second, the heavy and useful corn—and third, the intermediate or light corn. The winnowing-machine, attached to the thrashing-apparatus, performs, in a certain degree, these operations. The chaff is blown away, and is received into a separate chamber. The light grain is received at one aperture, and the heavy grain at another; but the winnowing-machine is so formed and regulated that a small portion only of the light grain is separated from the heavy. The greater part of the light and the heavy grain is made to come out at one aperture; while that which comes out at the other aperture is but a small proportion of the light mixed with pickles with the chaff attached, broken ears, and other substances. Now, the assistants in the dressing-barn collect in their riddles, first the heavy mixed with light corn, which falls from one aperture of the machine; and next the small proportion of light mixed with heavy substances, which falls from the other; and they proceed in the following manner:—

At the aperture from which the corn, properly so called, falls, they receive it in their riddles (Fig. 153), and riddle it into a heap. What falls through the riddle is corn; what is retained in the riddle is broken heads of corn, chaff, and other substances. This refuse is thrown aside, or more frequently it is thrown amongst the mass of similar substances which are falling from the second aperture of the machine. Now, with respect to the substances falling from this latter aperture, they are also collected by the attendants with riddles having much wider meshes, called slap-riddles

(Fig. 152), and riddled into a small heap. What falls through is corn mixed with chaff and other substances. What is retained is broken heads of corn, short straws, and the like. These are thrown aside as refuse, or carried again to the feeding-board, and passed through the thrashing-machine, so that the broken heads may be subjected to a further thrashing, and thus the remaining corn be separated from the straw.

There are now two heaps, one consisting of the great mass of corn, and the other much smaller, consisting chiefly of the light corn and chaff, which had passed through the meshes of the slap-riddle. This completes the operation of thrashing, as it is effected by the thrashing-machine and its attached fanners. The corn is now to be finally dressed and prepared for use in a separate winnowing-machine.

The winnowing-machine was before described. The corn, it was seen, is put into the hopper, and falling down upon the wirework below, is acted upon by the air of the fanners. The chaff is blown out at the end of the machine. The heavier corn falling down, is conveyed by an inclined plane to an aperture where it is received: while the inferior corn, not sufficiently light to be blown away with the chaff, nor sufficiently heavy to go with the superior grain, falls into an intermediate space, and thus is separated from the heavy grain on the one side, and the chaff on the other. Both the heavy and the light grain, which last is in comparatively very small quantity, are riddled into their respective heaps, and the refuse retained in the riddle is thrown aside.

In applying the winnowing-machine to complete the dressing of the corn, it is placed in a convenient situation near the corn to be winnowed. For bringing the corn from the heap to the hopper, close sieve-like implements (Fig. 154), capable of holding about half a bushel, are used. One person is sufficient for this duty, and for filling the corn into the hopper. One person may conveniently collect the heavy corn as it falls from the machine, and carry it in the same sieve-like implement to two persons employed in riddling, and divide each portion between them, by pouring it into their respective riddles. This, at least, is a convenient

distribution of labour, but the intermediate worker may be dispensed with. The persons employed in riddling, riddle the corn into its heap, and throw aside the refuse. The light or intermediate corn is riddled into a heap as it accumulates.

The whole corn, then, is divided into the following parts—first, the heavy or superior grain; second, the light or inferior grain; —and, third, the chaff, straw, and refuse.

The implements employed for these operations are—

1. The thrashing and winnowing machines already described.

2. The close implement for carrying corn, and the sieves for riddling or shaking it through. These last are sometimes made of wire, but they are more simply and better formed of splints of ash; the meshes being of different sizes, suited to the different kinds of grain.

Fig. 152.

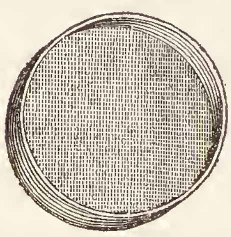


Fig. 153.

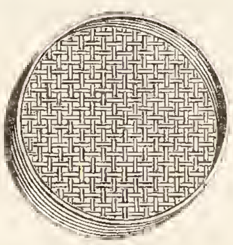


Fig. 154.

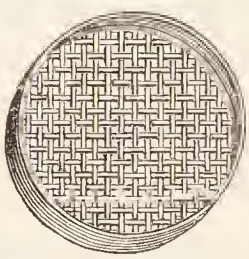
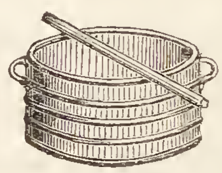


Fig. 155.



3. A vessel for measuring corn, with a flat stick or roller passing over the top and levelling the corn. This measure may contain a bushel. Fig. 155.

4. A wooden shovel for shovelling corn into heaps. Fig. 156.

5. A load-barrow for carrying filled sacks. Fig. 157.

Fig. 156.

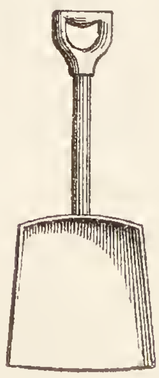
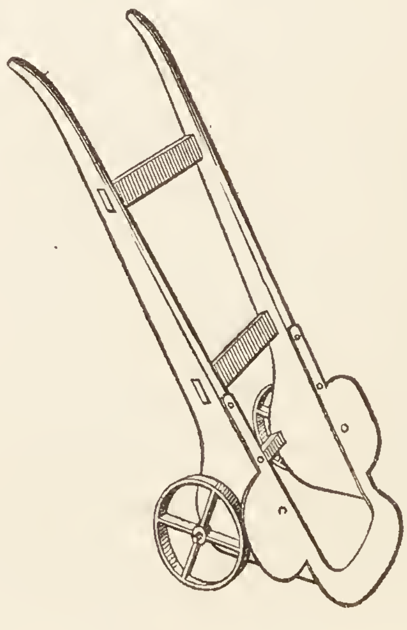


Fig. 157.



The heavy or superior grain is intended for the various purposes of consumption to which the different kinds are suited. The common practice of the farmer is to convey it as quickly as possible to the miller or intermediate trader in corn. For this purpose, as soon as it is winnowed in the manner described, it is measured, and put into sacks capable of holding a determinate quantity, as half a quarter. In these sacks it is conveyed to market; and sometimes, from particular causes, the farmer stores it in granaries, spreading it upon the floor until it is required for use.

The lighter or inferior grain is usually employed for the feeding of the animals upon the farm.

The straw is used for various purposes of domestic economy and the arts: but its main consumption upon the farm is for the purposes of provender and litter. The chaff also is used as fodder for cattle.

Of the straw of the different kinds of the cereal grasses, that of the oat is the most valued in this country for fodder; that of wheat and barley is chiefly used for litter. The quantity produced varies greatly. It may be held on a medium to weigh from 20 cwt. to 30 cwt. per acre. Wheat produces the greatest weight, oats the next, and barley the smallest, as well as the least valued also for its quality.

1. Wheat.

Having thus treated of the cereal grasses in general, we are prepared to consider the characters, uses, and modes of culture of each. They are divided into genera, and these again into species, and minor varieties or kinds. The first in the order of description of the genera, and the most important as the food of man, is Wheat.

Of the genus *Triticum*, the following species may be enumerated as admitting of cultivation for their seeds:—

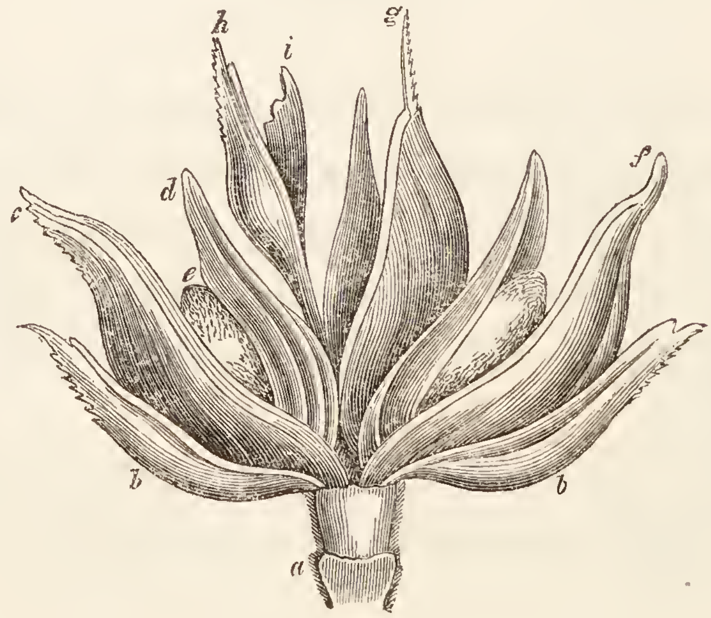
1. Triticum æstivum—Summer Wheat.
2. Triticum hybernum—Winter or Lammas Wheat.
3. Triticum compactum—Compact Wheat.
4. Triticum compositum—Egyptian Wheat.
5. Triticum turgidum—Turgid Wheat.
6. Triticum atratum—Dark-spiked Wheat.
7. Triticum hordeiforme—Barley-like Wheat.
8. Triticum Zea—Far.
9. Triticum Spelta—Spelt.
10. Triticum monococcum—One-grained Wheat.
11. Triticum polonicum—Polish Wheat.

Triticum æstivum, Summer wheat, has awns on both the two classes of valves, forming the calyx or glumes, and the corolla or paleæ. Each spikelet has usually five florets, of which two are barren.*

Summer wheat requires a shorter period to complete its vegetation than any of the other kinds. It is the prevailing species

* The calyx of wheat consists of two valves or glumes, enclosing several florets. Each of these florets has two valves, forming the corolla or paleæ, and enclosing the seed. Sometimes the paleæ enclose a perfect seed, and sometimes the seed is not perfected. Each calyx, with the florets which it encloses, is termed a spikelet. The part to which the spikelets are attached, is termed the rachis or shaft, and the spikelets, placed one above the other on each side of the rachis, form the ear or head. The rachis is jointed, and the spaces between the joints are termed the internodii. In the following magnified figure of a spikelet of *Triticum hybernum*, —*a* is a joint of the rachis,—*bb* the calyx, or calycine glumes,—*cd* the paleæ, or valves of the corolla,—*e* a seed,—*f* another floret with a perfect seed,—*g* a third perfect floret,—*h* a fourth imperfect or abortive floret—*i* a fifth imperfect or abortive floret.

Fig. 158.



of warmer countries, and is cultivated in many parts of Europe. It is described by the Roman writers in such a manner as to shew that it has preserved its distinctive characters to the present time. Its grains are, for the most part, small, and the produce of its straw is less than that of some other species, when cultivated under the same circumstances. The trials that have been made with it in this country have shewn it to be inferior in productiveness and quality to the better kinds of the winter wheat. The advantage which it possesses is the earlier period of its ripening, on which account it may be sown so late, even in this climate, as the beginning of May.

Triticum hybernum, Winter or Lammas wheat, is distinguished from the last, by having no awns upon the glumes, and only short awns upon the paleæ, near the summit of the spike. But the awns not being a good botanical character, many botanists have conceived the species to be the same. The characters of either kind being permanent, however, and remaining, under given circumstances, unchanged for an unknown period, they may be regarded as species. The winter wheat has usually five or six florets, of which two are barren.

Winter wheat is that which is the most important with relation to its cultivation in Northern Europe. It is, in this country, generally sown previously to the months of winter; but it is an annual plant, and may be sown in spring.

Triticum compactum, Compact wheat, is allied to the two last named species, and seems to be merely a variety of them. In it the internodii of the rachis are very short. It is partially produced in different parts of Europe. I have received specimens of it from France and from Sweden, and have cultivated them, without observing any change of characters. Whether, however, the characters which distinguish it are sufficiently permanent to entitle it to be regarded as a species, has not been determined. In the mean time, following the authority of Host,* I have placed it amongst the species.

Triticum compositum, Egyptian wheat, is distinguished from

* Icones et Descriptiones Graminum Austriacorum.

the others by its branched or compound spike. Its seeds are numerous, and the produce is abundant. It requires a good climate and a fertile soil; for in unfavourable situations the branches of the spike are not evolved, and then it assumes the appearance of ordinary wheat. It is cultivated in Egypt and the East, as it is in Spain and different parts of Italy. It was known in Germany about 250 years ago;* and in France it is said to have been cultivated for more than eighty years, having been brought from the East under the name of Wheat of Smyrna. In England it has been partially cultivated as the subject of experiment; but the grain has been found to be inferior in quality to that of the kinds in common cultivation.

In the next species, *Triticum turgidum*, Turgid wheat, the paleæ are awned, but not the glumes, the spikes are covered with soft hairs, and in some varieties change to a dark colour, and the awns drop off as the seeds become ripe; in which respects it differs from summer wheat. It is termed with us Grey wheat, Duck-bill wheat, Grey Pollard, Rivet, Pole-Rivet, Cone, Pendulum, &c.

This species grows very tall, with a thick and rigid stem. The spikes are large and heavy, and nod to one side as the grain increases in weight. The kinds or minor varieties are distinguished by the farmer from their qualities of earlier or later ripening, and greater or less productiveness. One of the most esteemed of these is Cone-wheat, so named from the conical form of its spike.

The turgid wheats are productive in corn and straw, but the grain is coarse and hard. They are chiefly suited to the inferior clays, upon which, in England, they are extensively cultivated. They are valued, under such circumstances, for their productiveness in grain, and their large growth of straw; but being inferior to the winter wheats in the quality of their produce, the cultivation of them is not likely to be extended in this country.

Triticum atratum, Dark-spiked wheat, is allied to the last species, if it is not rather to be regarded as a variety of it. I obtained it from Africa, and it is not improbable that the turgid

* Eicones Plantarum, Francofurti ad Moenum, MDXC.

wheats are derived from that country. The dark-spiked wheat has merely been made the subject of experiment, but not of extended cultivation. It is not superior in productiveness to the turgid wheats in common use.

Triticum hordeiforme, Barley-like wheat, so named from its peculiar form resembling that of barley, seems also to be derived from Africa. It resembles the last species by its florets being awned, and by its glumes and paleæ becoming dark as the seeds ripen. But it resembles the class to be next referred to, termed Spelt-wheat.

Triticum Zea, Far, is one of the class of spelt-wheats. It is distinguished by the distance of its spikelets from one another. The straw is rigid; the glumes and paleæ adhere closely to the seed, and the spikelets again so closely to the rachis, that they cannot be separated from it without breaking it. This wheat is cultivated in some parts of Europe on inferior soils.

The next species, *Triticum Spelta*, Spelt-wheat, is distinguished, like the last, by its spikelets being firmly attached to the rachis, and by the rigid valves of its glumes and paleæ closely enveloping the seed.

Spelt is much cultivated in the south of Europe. It is grown extensively in the southern provinces of France, in Switzerland, Italy, in several parts of Germany, and in Arragon, Catalonia, and other parts of Spain.

Spelt could be raised in this country with facility, and, it is probable, on soils low in the scale of fertility. It has been cultivated in Scotland, 600 feet above the level of the sea.

The next species is *Triticum monococcum*, One-grained wheat. Its spikelet consists of three or four florets, one of which only is for the most part fertile, and hence its name, one-grained wheat. The fertile floret has a long awn. It is readily distinguished from all the other wheats by its general appearance, in which it resembles barley. Its stem is slender and rigid. It is allied to the spelts, with which it was classed by some of the older botanical writers. This species is cultivated in the mountainous parts of Europe, and on barren soils. It has never

formed an object of cultivation in this country, and does not appear to possess properties to entitle it to be introduced. This species has its varieties.

The last species to be mentioned is *Triticum polonicum*, Polish wheat. It has long awns, and is distinguished from all the others by its long and leafy glumes and paleæ. It is cultivated in Spain, and the countries of the Mediterranean. It has been cultivated partially, too, in some counties of England, where it is said to have been valued on account of its productiveness of flour. But, although it may be possessed of this quality, its florets are often infertile, and it does not merit a more extended culture in this country.

Of the species, or very permanent varieties, which have been enumerated, greatly the most important in the rural economy of this country is the winter-wheat.

The kinds of it are very numerous, and in truth, there is scarcely a limit to the differences which climate, situation, and soil may produce. The characters which it thus acquires in the different conditions in which it is placed, are more or less permanent and important.

The kinds are distinguished by a great variety of local terms, derived from their qualities, their places of growth, and other circumstances, as Kentish-yellow, Burwell-red, Golden-ear, Essex-dun, Velvet-ear, and the like. With respect to their uses in agriculture, they may be divided into two classes, distinguished by the colour of their seeds, red and white; and these again may be distinguished by their spikelets being smooth or hairy, the one being termed thin or smooth-chaffed, and the other thick or woolly-chaffed. Of these classes, the white are superior in the quality of their produce; the red are the more hardy; and, in general, the thin and smooth-chaffed are preferred to the woolly and thick-chaffed.

Winter-wheat is sometimes termed spring-wheat. This merely arises from the period of sowing. If it is sown in spring, it is termed spring-wheat; if previously to winter, Lammas or winter wheat. This circumstance has perplexed some writers, who have

evidently drawn distinctions between the winter and spring wheat of the farmer which do not exist. But it is a curious fact that wheat, by being sown in spring, changes its habit with relation to the period of ripening. The produce of wheat sown in spring acquires the habit of ripening earlier than the produce of wheat sown in autumn ; hence the farmer, when he sows wheat in spring, should sow the produce of that which had been already sown in spring, and not the produce of that which had been sown in autumn. This change in the habit of ripening takes place in the case of all the cerealia, and many other cultivated plants.

The minor varieties of any species of wheat are not permanent in their characters, though, under given conditions, they will remain unchanged for an indefinite period. Under other circumstances, however, they degenerate ; and hence particular kinds that were once valued have now ceased to be so.

Wheat is of very general cultivation on all classes of soils ; but the soils which are best suited to it are those which are more or less clayey. So peculiarly is wheat suited to the stiffer soils, that these are familiarly termed wheat-soils. The soils of the lightest class are the least suited to wheat ; and it is an error in practice to force the production of wheat on soils, and under circumstances, which are better suited to the production of the other cerealia. Wheat in this country does not admit of being cultivated at a great elevation. A general rule, applicable to all cases in which wheat is sown, is, that the land shall be in the best condition that circumstances allow, with respect to tillage, cleanness, and fertility. As wheat is the most valuable of the cereal grasses, so it requires greater care than the others to produce it. It is an error to sow with a corn-crop any land which is out of order ; but this error is greater and more hurtful in the case of wheat than of most of the other cerealia.

Wheat is always to be sown before winter when the land can be then prepared to receive it. The sowing of it is deferred till spring, when the crops which it is to succeed in the rotation cannot be removed till that season. It is sown before winter after summer-fallow, potatoes, or beans, because, in all these cases, the

ground can be fitted to receive the seeds at that time. It is sown in spring after turnips, cabbages, and such other crops as are not usually removed from the ground till spring.

The fitting place of wheat in the rotation is upon land that has been in summer-fallow. In this case, the land is to receive, previously to the wheat being sown, what is termed the seed-furrow; as soon after which as convenient the seeds may be sown. The best period for sowing is from about the middle to the end of September. The seeds, previously to being sown, undergo an operation peculiar to wheat, termed pickling or steeping. This is intended to prevent a disease to which the cultivated Tritica are subject, termed *smut*. The best substance which can be employed for the purpose of steeping is stale human urine, which should be in readiness when the period of sowing arrives. The process of steeping may be thus performed:—

Let a tub be provided, and partly filled with urine, and let a quantity of wheat, as a bushel, be put in at a time. Let the wheat be well stirred, and let all the lighter grains which come to the top be skimmed carefully off and thrown aside as useless. The wheat should remain from five to ten minutes, but never more than ten minutes, in the pickle. The successive portions of wheat thus pickled are to be allowed to drain a little, and then to be laid upon the barn-floor in layers, hot lime being at the same time sifted upon each layer. The purpose of spreading the lime is to dry the grain, which should then be carried immediately to the fields and sown. The lime used should be quite hot, and for this purpose it should be slacked at the time. Although the immediate purpose served by the application of lime is drying the grain, it may be believed that it also assists the action of the brine in removing the tendency to the disease.

A very strong pickle of salt dissolved in water may be used instead of urine; but salt-brine is not quite so secure a mean of preventing the disease as urine; and the latter, therefore, ought to be preferred.

The wheat, after being pickled, must not remain long unsown, otherwise its vegetative powers may be injured or destroyed. No

more should be pickled at a time than can be then sown. When, from any cause, as from rain intervening, it is not practicable to sow the wheat for a day or two, it should be spread thinly upon the floor, but never kept in sacks, in which it would soon ferment.

The wheat, when pickled, then, is to be carried directly to the field. It may be sown, either by the hand or by the broadcast sowing-machine, in the manner already described, or in rows by the drill-machine.

When it is sown in drills, the usual distance between the rows is from 9 to 12 inches; but it is conceived that the larger intervals are the better, and that they may, in most cases, be with advantage more than 12 inches.

The quantity of seeds usually sown is from two to three bushels to the acre. In the case of summer-fallow, the quantity need not exceed two bushels to the acre. When the sowing takes place in spring, the quantity may be extended to three bushels, but rather less than more.

When the seeds are sown by the drill-machine, a single or a double turn of the harrows will suffice. When they are sown broadcast, the land must receive several harrowings, but no more than are sufficient to cover the seeds, it being better in the case of wheat that there be a certain roughness of clod. A double turn along the ridge, a double turn across, and again a single turn along, will in almost every case suffice ; and often less, namely, a double turn along, a single turn across, and a single turn along; but many farmers prefer finishing with a turn across.

No sooner is the process of harrowing executed than the land is to be water-furrowed in the following manner :—The common plough, with one horse, is to pass once along each water-furrow, and then along the water-furrows of the headlands, and to draw further open furrows in such hollows of the field as water might stagnate in. A person is then to follow with a spade, to clear out the water-furrow of the headlands to the necessary depth ; to make channels through the headlands to the ditch, where necessary ; to clear out the cross-furrows in the hollows, so as to allow

the water to run; and to open up the intersections of the water-furrows of the ridges with these cross-furrows, and the water-furrows of the headlands.

The best period of sowing, it has been said, is from about the middle to the end of September. The early part of October, however, is well suited to the sowing of wheat, and it may be continued till the middle of November, or later.

Wheat may be advantageously sown after potatoes. This crop is generally removed from the ground early in October, which admits of the wheat being sown before winter. In the case of this crop, the land being first harrowed, it is then formed into ridges, and the wheat is sown upon these, precisely as in the case of summer-fallow.

Wheat may be sown after a crop of beans, before winter. When the beans are removed from the ground, the land should be well harrowed across, the effect of which is to level it. The ridges are then to be ploughed by gathering the old ridges, the traces of which are not generally obliterated. The wheat is then to be sown precisely as in the case of summer-fallow; and the same careful attention is necessary, as in all other cases, to the clearing out of the water-furrows and cross-channels, so that no water may stagnate upon the surface.

Wheat may be sown after pease, and then the management is the same as in the case of beans.

Wheat may be sown after turnips, and other plants of the cabbage family. If they can be removed before winter, the wheat may be sown at that time; but as these plants generally are not removed from the ground till spring, the wheat is in this case sown in spring. The land is ridged up once, and sometimes receives in addition a seed-furrow, and the wheat is sown as in the case of summer-fallow or potatoes.

Wheat may also be sown after beet, carrots, and parsneps, and is treated precisely in the same manner as when sown after turnips. If the crops can be removed before winter, the wheat is then to be sown; if not, it is to be sown in spring, and the more early in spring the better.

Wheat may be sown after clover and the cultivated grasses. But this is not the true place of wheat in the rotation, oats being the crop that can generally be most advantageously sown after grass. When wheat, however, is sown after these plants, the land may be ploughed once, and the wheat sown in autumn. Sometimes a partial fallowing is given; but this is unnecessary.

A practice prevails in certain parts of England, of planting the wheat upon the clover-ley by dibbling. In this case, the furrow-slice is laid flat, and a light roller made to pass over it. A man walking backwards with an iron dibble in each hand, strikes two rows of holes in each sod, and he is followed by children, who drop a few grains into each hole; the seed is covered by a bush-harrow, and sometimes by a roller. The quantity of seeds is from a bushel, or even less, to a bushel and a half per acre. Although a seemingly inartificial and rude process, and unsuited to that despatch which is deemed essential on well-managed farms, it is yet found to answer well on the loose and sandy soils on which it is practised.

Wheat, and all the cerealia, have the property of sending out numerous shoots from the roots during their growth. This natural process is termed tillering, and is familiar to all farmers.

It is to be observed, too, that often the roots of the grasses are partially raised above ground, in which case the plant becomes feeble or perishes. This accident sometimes occurs from too thick sowing, and too rapid a growth in that state. But it is more often produced by the sudden contraction and expansion of the soil by alternate frosts and thaws in winter, and in this case the wheat is said to be thrown out.

To promote the process of tillering, and sometimes to prevent the throwing out of the plants, it is found to be beneficial to give a certain tillage to the growing wheat in spring, by means of the hoe, the harrow, or the roller. When wheat is sown in rows, this is done by means of the hoe; when broadcast, by means of the harrow; and in either case the roller may be also used. But this tillage is generally given to it incidentally, and in the course

of another operation to be described,—the sowing of the seeds of the clovers and cultivated grasses.

The seeds of these plants are sown as early as convenient in April upon the surface of land on which the cereal grasses are sown. They grow up under the shade of the latter, and in the following season they are fit for use. When the crops of corn with which they are to be sown, are sown in spring, they are generally sown at the same time: But when the crop, as of wheat, has been sown in the previous autumn, the grass-seeds are sown amongst the growing plants, and covered by being harrowed or rolled.

The minute seeds of these plants, consisting of the clovers, and of the ryegrass, or other grasses, are, previously to being sown, carefully mixed together. They are then brought to the ground in sacks, and sown by the hand, or what is better, by the broadcast sowing-machine. In either case, the harrow follows, giving a double turn along the ridge, and the roller may also follow, crossing the ridges, and going over the ground once. In some cases the roller alone is used to cover the seeds.

When the crop is in rows, and hoeing is practised, the seeds may be sown just before the hoeing is given, which then serves the purpose of the harrow. But it is better that the hoeing first takes place, and that the seeds be afterwards sown.

The clovers and grasses thus sown, rarely flower in the first year. They grow under shelter of the stems of the larger crop, and they are seen in autumn amongst the stuble covering the surface. They grow during the autumn and winter months, shoot vigorously forth in spring, and are in their greatest luxuriance in the following summer, when they are frequently termed new or one-year-old grass.

The grass-seeds being sown, no further culture can be given to the wheat, during its growth, nor any weeding, except pulling up or cutting over above ground the larger weeds, as docks, thistles, cockle, and the like.

Wheat sometimes becomes too luxuriant in spring, especially when sown early, and then it is apt to be lodged, and run to straw

more than to produce grain. In this case, it may be depastured for a short time in the early part of spring with sheep.

The next process in the progress of the wheat-culture is that of reaping, the method of performing which is the same as that before described.

The produce of this crop varies greatly with the seasons, the nature of the soil, and the mode of cultivation. A fair good crop may be held to be thirty bushels per acre. The average produce of the kingdom does not, perhaps, exceed twenty-five bushels to the acre. The weight of the straw is reckoned to be about double that of the grain. An acre, therefore, yielding twenty-five bushels of grain, at the rate of 60 lb. per bushel, would yield 3000 lb. of straw, or about 26½ cwt.

The uses to which this grain is applied are numerous and well known.

It is beyond every other grain adapted to the making of bread. It owes this preference chiefly to the greater quantity of gluten which it contains, and to its greater nutritive properties. It is used in various other ways for food. Starch for domestic uses is also derived from it. The grain, being steeped, is beaten in hempen bags in water, and thus the starch is separated.

The straw is applied to various purposes of rural economy and the arts. It is used for litter, for which it is well suited. It is used also for provender, but is not so much esteemed for this purpose as the straw of the oat, although more than that of barley. In other countries of Europe, however, it is that which is most esteemed for provender, being generally reduced to chaff. It is used for thatching, to which, from its long and rigid stems, it is well suited. It is used for making baskets, bee-hives, mats, and similar articles; and for the manufacture of hats. The straw, in this latter case, is grown very fine, by being closely sown; it is pulled green, and bleached upon the surface of the ground. The *grano marzolano* of Italy, employed in the manufacture of the Leghorn hats, is a variety of summer-wheat.

Wheat is subject to various accidents and diseases, some of them peculiar to itself. The most dreaded and destructive of these

is *blight*, so termed from its effects upon the ear, or *mildew*, from its supposed cause, namely, *mel-dew*, from an old opinion, that it was produced by honey-dew falling from the air.

This disease is indicated by the presence of certain minute plants of the order of *Fungi*, or the mushroom tribe, which grow upon the stem and leaves, and doubtless feed upon and exhaust the juices of the plant. When this occurs at a period so late that the seed is already formed, it does not materially affect it, the straw alone suffering in this case. But when it occurs when the seed is still in an embryo state, the further progress of the seed to maturity is arrested; and it is found, when cut down, to be shrivelled and abortive.

One of this tribe of plants, and apparently the most destructive, is *Puccinia graminis*, which appears in the form of small spots upon the stem, and gradually extends in lines on the surface. Vast losses have been sustained by the blight produced by this cause.

A disease termed *rust* is also very frequent and hurtful. It appears in the form of a brownish dust upon the stem and leaves; and it is produced likewise by a parasitical plant of the same family.

Another disease of wheat, produced also by minute fungous plants, is *smut*, which differs from rust and mildew in this, that the means of prevention are generally within our power.

There are two varieties of smut. The first resembles a black dust, growing within the glumes of the wheat. It destroys the seed and its envelopes, converting them into a black powder, known by the name of brand, dust-brand, burnt corn, &c. This species is *Uredo segetum*.

The other variety is like a brownish-black dust, consisting of larger grains than the last. It does not appear externally, but fills the seed with a fetid powder; and is greatly the most destructive of the two. It is known to farmers under the name of smut, or ball. The fungus has been termed *Uredo caries* by M. De Candolle. When affected with this disease, the seed is said to be smutty, blacked, or balled. If the number of grains affected is

considerable, the loss is important, both by lessening the produce, and tainting what remains with the black dust of the balls.

Farmers, when their wheat is greatly injured by this disease, sometimes wash it, by immersing it in vats or cisterns partly filled with water. The smut-balls and lighter grains floating to the surface are skimmed off, and the heavy and sound grain, after being washed, is exposed to the air to dry, or dried in a kiln with a moderate heat. This practice, however, is rare; and industrious winnowing is the usual method resorted to for freeing the grain from the intermixed balls.

That this disease is conveyed from the grain to the future plants, may be inferred from the effects of brine and caustic substances upon the grain, as employed in the process of pickling. It has been supposed by some, that the almost impalpable seeds of the fungi are carried upwards by the ascending sap.

These and other diseases of the wheat arise from the growth of parasitic plants, favoured and developed, it may be believed, by circumstances unknown to us. Another class of diseases is produced by the attacks of animals.

Of these the most common, in the early stages of the growth of the plant, are the larvæ of certain beetles. They pass among agriculturists under the general name of grub.

Certain flies also attack the wheat at a later stage of its growth. The *Cecidomya Tritici* is a fly with an orange-coloured body and white wings. About the month of June, the female ascends the ears of wheat, and deposits her eggs by means of a fine trunk, and in a few days she perishes. The progeny being hatched in the ear, feed upon the grain. They are very small, from ten to fourteen being sometimes found in one grain, and are distinguished by being of a bright orange colour. They do not extend beyond the grain in which they had been produced; but several grains being thus consumed on each ear, the damage done is often considerable. The larvæ, after a period, fall down to the earth, in which they burrow, and remain there till the following summer, when they ascend from the earth in the form of the beautiful fly which has been mentioned.

These are the principal accidents to which the wheat-plant is subject in this country, from animals and diseases. When stored in the granary, it is subject to the attacks of the weevil and other creatures.

2. Rye.

Of the genus *Secale* there is one species cultivated for its ripened seeds—

Secale Cereale—Rye.

Rye is extensively cultivated in Europe, forming the main part of the bread-corn of the inhabitants of a great part of Germany, Poland, Russia, Switzerland, and other countries.

Rye, with respect to its mode of cultivation, resembles wheat; but it can be grown upon inferior soils, and with less of culture and manure. It differs from wheat in this, that while wheat affects a clayey soil, rye succeeds on a light and sandy soil.

Rye may be sown in autumn, or it may be sown in spring; and this circumstance affects, as in the case of other cerealia, the habits of ripening of the plant. When sown in autumn, it is termed winter-rye, and when sown in spring, spring-rye. The winter-rye is sown in autumn at the same time as wheat; the spring-rye with the oats, or as early in spring as the weather will allow. Rye shoots into the ear sooner than wheat, and ripens earlier. It stands drought better than wheat, but is more apt to suffer injury from wetness. It is a hardier plant than wheat, and less subject to the attacks of insects and diseases.

Rye is in various countries sown mixed with wheat. The mixture is termed meslin in England; and the two kinds tend to ripen at the same time when sown together.

Rye is sometimes sown for yielding herbage in spring, and green forage at a later season. Where turnips, however, and the cultivated grasses are raised, this practice is little adopted.

The bread of rye is dark, sweet, and nutritious, though in this latter property it is inferior to wheat. Mixed in certain proportions with wheat, it makes a palatable and wholesome bread.

Coarsely ground, and mixed with the meal of other grains, it is in some countries made into a kind of bread for the feeding of horses and other animals. It is used extensively, in the north of Europe, for the purpose of distillation.

Rye rises to a greater height than wheat, and produces a thinner stem, but a great weight of straw. The straw is hard, wiry, and little valued for fodder; but it is used for thatch and other purposes. It is well suited for the manufacture of straw-hats; and, when intended for this latter purpose, it is sown very thick, pulled green, and blanched by exposure to the air.

Rye, though free from the diseases of wheat, is yet subject to a peculiar one. This is the ergot, a fungous growth, which, though it is found on other gramineous plants, is more especially the disease of rye. It is a long cartilaginous-like substance, projecting from the grain, and often taking the place of it. It chiefly prevails in humid seasons, in close situations, or where the soil is wet. Animals, when in a state of liberty, refuse it; and when used in quantity amongst bread, it is said to be pernicious, producing gangrene.

The manner of cultivating and managing the rye-crop, is in all essential points the same as that of wheat.

3. Barley.

Of the genus *Hordeum*, the following species may be enumerated as cultivated for their seeds:—

1. Hordeum distichum—Two-rowed Barley.
2. Hordeum gymno-distichum—Two-rowed Naked Barley.
3. Hordeum disticho-zeocriton — Two-rowed Sprat or Battledore Barley.
4. Hordeum hexastichum—Six-rowed Barley.
5. Hordeum gymno-hexastichum—Six-rowed Naked Barley.
6. Hordeum hexasticho-zeocriton—Six-rowed Sprat or Battledore Barley.*

* Barley differs from wheat in this, that each floret has its own calyx. The

Hordeum distichum, Two-rowed barley, is the species in common cultivation. The spike is composed of two rows of perfect seeds, the paleæ remaining closely attached to, and covering, the seeds. The minor varieties of two-rowed barley are numerous, and are distinguished chiefly by the quality of their grain, and by their habit of early or later ripening; and some varieties are more productive than others;—effects apparently dependent upon differences of climate and situation.

Barley is an annual plant; but, like wheat, it may be sown in autumn, and then it acquires the habit of later ripening, and is termed winter-barley.

Two-rowed barley is sometimes, from the colour of its paleæ

florets are placed in threes on each of the two sides of the rachis. Sometimes all the three florets on each side are fertile, producing seeds, when the barley is termed six-rowed: sometimes only one floret of the three is fertile, when the barley is termed two-rowed. In the following figure the three florets are represented as fertile: *a* is a joint of the rachis; *b* and *c* are the two glumes of the calyx; *e* is the inner valve of the corolla, *d* is the outer valve, of which the awn *f* is a continuation; *h* is another floret, shewing the same parts; and *g* is another floret, also shewing the same parts, excepting the inner valve of the corolla.

Fig. 159.

or inner husks, black. This creates a great difference in the external appearance of the grain, but is not to be regarded as a permanent character.

The paleæ of this species, as has been said, are closely attached to the grain, and form its covering. But sometimes they are not attached to the grain, and in this case the seed is commonly said to be naked, in which respect it resembles wheat. It is not determined whether this be a permanent character, but in the absence of proof to the contrary, it may be assumed to be so, and the naked barley held to be a species. It may be termed *Hordeum gymno-distichum*.

Two-rowed naked barley is said to have been introduced into England in the year 1768. It is now little cultivated, and is by some asserted, though without any evidence, to merge into the common species. It has been in cultivation in some parts of Europe, and has preserved its characters, for a period beyond all record.

The next species, commonly termed *Hordeum Zeocriton*, has been here termed *Hordeum disticho-zeocriton*, Two-rowed sprat or battledore barley. The spike is short and conical, the awns long and spreading, and the seeds more compressed than in the other species. As in the other species, the three contiguous florets on the spike may perfect one seed, forming two-rowed barley; or they may perfect all the seeds, forming six-rowed barley. This species is scarcely cultivated in this island, the shortness of its straw being regarded as an objection to its cultivation.

The next species is *Hordeum hexastichum*, Six-rowed barley. When sown before winter, this species acquires the habit of late ripening, and is then termed winter-barley. Winter-barley is very frequently cultivated in the countries of the north of Europe.

One of the kinds of six-rowed barley, and the best known in this country, is bere or bigg. Bigg ripens its seeds in a shorter period than the two-rowed barleys. It is cultivated in the north

of Scotland, in Denmark, Sweden, and other parts of Europe. The number of its grains is greater than in the two-rowed kinds, but they do not weigh so heavy in proportion to their bulk. It is hence regarded as an inferior crop, and is only cultivated in the more elevated parts of the country. It ripens very early when sown in spring, and hence the advantages which it possesses in a late climate.

Sometimes the external cover of the grain, as in the case of the two-rowed barley, is black. This arises in either case from the change of the colour of the paleæ in ripening.

The paleæ of this species adhere closely to the grain, and form its covering. Sometimes, however, as in the case of the two-rowed naked barley, the paleæ are detached from the grain. Whether this be a permanent character is not determined; but in the absence of proof to the contrary, it may be assumed to be so, in which case it must be regarded as a species. It has been termed *Hordeum gymno-hexastichum.*

The six-rowed naked barley is cultivated in various parts of Europe, and is greatly esteemed for its fertility. In some parts of Germany, it is regarded as the most valuable kind of barley, and by the French, on account of its supposed productiveness, it has been termed *orge céleste.* This, and the other superior kinds of six-rowed barley, deserve more attention than they have yet received. Almost the only kind cultivated in Britain is bere or bigg, which occupies an inferior place.

A variety of this species lately brought from Nepaul, has, in place of awns, soft hooked appendages at the termination of the valves of the corolla. These tend to disappear by the effects of acclimating in this country, and to pass into awns. This remarkable variety is cultivated in Tartary, 10,000 feet above the level of the sea.

The last of the species to be mentioned is *Hordeum hexasticho-zeocriton,* Six-rowed sprat or battledore barley. This has been sometimes termed six-rowed barley: whereas the characters of six-rowed does not belong to it alone. An examination of the

plant will shew that it is the common battledore barley, with all the florets fertile.*

Thus, the kinds of barley which may be cultivated, are,—

1. The two-rowed kind, in which the valves of the corolla adhere to the seed.

2. The two-rowed kind, in which the valves do not adhere to the seed.

3. The two-rowed battledore barley.

4. The six-rowed kind, in which the valves adhere to the seed.

5. The six-rowed kind, in which the valves do not adhere to the seed.

6. The six-rowed battledore barley.

Barley, it has been said, may be sown either in spring or in autumn. It is more frequently sown in spring.

Barley is an early-ripening grain, and therefore it may be sown at a late period, as the month of May; but the usual period is April, and the sooner the better. The more early that barley can be sown the produce in grain is the surer, though the bulk of straw will be less. It may be sown at any time at which spring-wheat can be sown.

In the rotation of crops, barley may succeed to summer-fallow,

* Much confusion has arisen in the arrangement, by agriculturists, of the cultivated barleys, and in an especial degree by their speaking of four-rowed and six-rowed kinds. There is, however, no barley to which the term four-rowed can be applied. Barley is termed two-rowed or six-rowed, according to the number of its fertile florets. In two-rowed barley, one row of florets on each of the two sides of the spike is fertile, and consequently one row of seeds on each side is perfected. In six-rowed barley, three rows on each side of the spike are fertile, and consequently three rows on each side are perfected. In this sense only it is termed six-rowed barley. But there is no species known to us in which only two rows on each side of the spike are fertile. Slightly examined, indeed, six-rowed barleys frequently present the appearance of four rows; but this is in appearance only, for such barleys have always the three rows on each side perfect. In poor soils, and unfavourable situations, two of the rows run much into each other, and this has perhaps given rise to the mistake; but the two rows which thus run into each other in appearance, are on the opposite sides of the rachis.

I have ventured to propose a new arrangement of the cultivated barleys; under which, it will be seen that the *Hordeum vulgare* of some botanists is *Hordeum hexastichum,* and that the *Hordeum hexastichum* of some botanists is *Hordeum hexasticho-zeocriton*. Yet I do not assert that some of these ought not to be deemed varieties, rather than species.

to potatoes, turnips, or any other green-crop, and to any of the pulse-crops.

When barley follows a summer-fallow, it is common, after ridging up the land in the manner described for wheat, to leave it in that state till spring, when it receives the seed-furrow, and when the barley is sown. It is a rule observed in the case of barley, always to sow on a freshly stirred soil. It is for this reason that the seed-furrow is deferred till spring, and given when the land is dry, just before the barley is sown. The grubber may sometimes, with advantage and economy, be employed to give this spring tillage.

When barley is sown after potatoes, the land is ridged up when the potatoes are removed, generally in October. It remains in this state till spring, when it receives a final ploughing or seed-furrow immediately before the seeds are sown.

Barley, however, is rarely sown after summer-fallow or potatoes, because the land is then prepared for the more valuable crop, wheat. When barley, therefore, is sown in either of these cases, it may be regarded as an exception to the general rule.

Barley may be sown after beans. In this case the land, after the beans are removed, receives one or more ploughings in autumn, and is ridged up so as to remain dry. In spring it receives another ploughing, and sometimes two, immediately after which the seeds are sown. Wheat, however, is the grain which, in the more general course, follows beans; first, because it is the more valuable crop, and, second, because the soils suited to beans are those also suited to wheat.

When barley is sown after pease, the mode of management is the same as in the case of beans.

In the cases that have been mentioned, barley might be sown previously to winter. But the practice of sowing winter-barley is rare in this country. When from any cause, however, it is found expedient to sow barley in place of wheat after summer-fallow, potatoes, or pulse-crops, the winter-barley might be sown with advantage. In this case it will be necessary to obtain the seed of some of the winter-sown barleys in cultivation, and not to

employ those which have acquired the habit of ripening in the same year.

Barley, it has been said, may be sown after turnips or other green-crops, and these are precisely the kinds of crops which form the best preparative for barley. They are grown for the most part upon light soils, and the lighter soils are those to which barley is suited. These crops also are not generally removed till spring, and spring is a proper season for sowing barley. Barley, therefore, is better suited to follow such crops than wheat is. It is also generally better suited to follow them than oats, because oats are the less valuable crop. These circumstances concur in indicating that the proper place in the rotation for barley is in succession to turnips and similar crops, which remain on the ground till spring.

When barley is sown after turnips and other green-crops in spring, the land should be ploughed once, and immediately after the ploughing, the barley should be sown. But when the period of sowing is late, and the ground is hard from the effects of drought or any other cause, two ploughings are to be given to reduce the ground to a finer tilth. In this case the harrow and the roller are also employed; and the grubber is well suited for the same purpose.

When barley succeeds turnips and similar crops, which are removed before winter, or at a very early period in spring, then the land should be ploughed into ridges immediately. When the season for sowing the barley arrives, a second ploughing or seed-furrow should be given.

Barley may be sown broadcast, or in rows, giving it a single turn of the harrows after the drill-machine, and just a sufficient number of harrowings to cover the seed in the case of broadcast sowing.

It is always found beneficial to roll this species of crop. The operation of rolling may either take place immediately after the conclusion of the process of harrowing, or after the plants are above ground. But the roller, on being employed for the covering of the grass-seeds which are sown with this crop, also effects

the purpose of smoothing and consolidating the surface of the land. The time of using the roller, therefore, is immediately after the grass-seeds are sown.

The quantity of seeds of barley generally varies from $2\frac{1}{2}$ to 3 bushels to the acre, when sown broadcast; but when sown in rows, the quantity of seed need not exceed 2 bushels to the acre.

The seeds of clovers and grasses are also sown with barley as with wheat. They may be sown either at the time at which the barley is sown, or when the plants are above ground. If this is done at the same time with the barley, the seeds are sown just before the last turn of the harrows, and are then covered, first by the last turn of the harrows, and then by the roller; or they may be sown after the land is harrowed, and covered by the roller alone. When the grass-seeds cannot be sown at the same time with the barley, then they are to be covered, when the time of sowing them arrives, by the roller alone without the harrows. When the barley is sown in rows, it may be hoed once previously to the grass-seeds being sown.

After the grass-seeds are sown, the barley-land admits of no further tillage. Should any large weeds appear, they may be pulled up by the hand; but it is the evidence of bad husbandry, if a spring-sown barley-crop requires weeding during the comparatively short period in which it is on the ground.

When the period of harvest arrives, barley must be allowed to be sufficiently ripe, but not to become what is termed dead-ripe. It may be cut either by the scythe or the sickle.

Barley, on account of the softness of its stem, and tendency of its ears to vegetate, is more apt to be injured, and even destroyed, by wet weather, than any of the other cereal grasses. For this reason, the safer course, in a humid climate like ours, is to place it, when cut down, in sheaves and shocks, and not to allow it, as is frequently practised, to lie loose upon the ground.

Barley being more subject to injury from heating, requires more precautions in the securing of it than any other grain. By heating in the stack, it quickly becomes discoloured and injured.

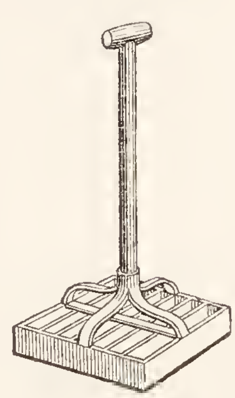
It is thrashed and prepared in the same manner as wheat; but

it has this peculiarity, that the awns of the corolla adhere to the seeds, and are with some difficulty broken off, especially when the season has been unfavourable, and the seeds have ripened imperfectly.

The thrashing-machine, if sufficiently powerful, will generally break off the awns, or may be made to do so, by making the cover of the cylinder rough internally, and bringing it near to the beaters, so as to leave a small space between them and the cover. But in less powerful machines, in which the breaking off of the awns is imperfectly performed, it is a frequent practice to put the thrashed barley again through the thrashing-machine, in order that, by the further agitation which it undergoes, the awns may be broken.

Sometimes a species of machinery driven by the power which moves the thrashing-machine is applied to this purpose. It is formed upon the principle of skutching. The skutchers are arms fixed to a vertical spindle enclosed within a cylinder. There are several tiers of these arms one above the other; the barley, being put in at the top of the cylinder, is acted upon by the tiers of skutchers kept in rapid motion, and so the awns are broken off.

Fig. 160.



But when the thrashing-machine is not in use, or performs its work imperfectly, an instrument worked by the hand, termed a hummeller, is employed. This consists of a set of parallel iron plates fixed to a frame, and worked by the hand like a pavier's instrument. Sometimes there are two sets of plates, the one crossing the other. The barley to be hummelled is laid upon the barn-floor, and, by repeated strokes of the hummeller, is freed from its awns.

The produce of barley, like that of all grains, varies greatly with seasons, culture, and soil. A medium crop is generally held to be about 40 bushels to the acre, and 60 bushels are a large return. The medium weight of two-rowed barley is about 55 lb. per bushel.

Barley is employed for various purposes. The flour is used in

some parts for bread; but the bread, though sufficiently nutritious, is dark and strong-tasted.

Barley is subjected to a species of grinding, by which the external coat of the seed is rubbed off. In this state it is termed pot or pearl barley, and is employed largely in soups, gruel, and cooling drinks.

It is used in the south of Europe for the feeding of horses; but in this country, the oat is regarded as the proper food of the horse. It is also employed for the feeding of hogs or other live-stock. In the practice of the farm, the light or inferior barley is generally used for this purpose. This, after being boiled or steamed, furnishes a cooling and laxative food for horses and other animals.

But the great consumption of barley is for malting, to which purpose it is excellently suited.

The straw of barley is employed partially for fodder, but chiefly for litter. It is lighter than the straw of oats and wheat, and less esteemed than either. The awns of barley are given to stock, either in their natural state or boiled.

The diseases of barley are not so numerous or fatal as those of wheat. It is attacked by the larvæ of certain flies. It is also subject to smut, though in a partial degree, and the fungus is usually *Uredo segetum.*

4. Oats.

The oat is of the genus *Avena.* The following species are those chiefly cultivated for their seeds:—

1. Avena strigosa—Bristle-pointed Oat.
2. Avena brevis—Short Oat.
3. Avena sativa—Common Oat.
4. Avena orientalis—Tartarian Oat.
5. Avena nuda—Naked Oat.

The first of these species is distinguished by the two lower florets of the spikelets having each three awns, the dorsal one very

long and twisted, the others short and straight. This is a native species of inferior properties, but sometimes cultivated, as in the remoter Highlands of Scotland.

Avena brevis, Short oat, is, like the last, of inferior quality. The seeds are numerous, but small. It is cultivated in the more mountainous and central parts of France and elsewhere.

Avena sativa, Common oat, is that which is more generally cultivated. Each spikelet contains two, and sometimes three, perfect seeds. The florets are sometimes awned, and sometimes destitute of awns.

Avena orientalis, Tartarian oat, is cultivated in England, and largely in some other parts of Europe. Its panicle is contracted, and nods to a side, which distinguishes it from the last-mentioned species. The colour of its corolla is generally dark, but the plant improves by culture in a good soil, losing its awns, and that darkness of colour which appears to distinguish the oat in its less improved state.

Avena nuda, Naked oat. In the species that have been mentioned, the corolla adheres closely to the seed and forms its covering. In this species, the paleæ are detached from the seed, as in the case of wheat and naked barley. It is from this property that this oat has obtained the name of pilcorn or peelcorn. It has been cultivated for an unknown period in Europe, is mentioned by our early writers, and was once in general cultivation in Scotland, and other parts of the island. It is said to be productive, and the meal to be fine.

The oat is the natural inhabitant of colder latitudes. It degenerates in the warmer parts of the temperate zone, and in lower latitudes disappears from cultivation. It is, of all the cereal grasses, that which is the most easily cultivated, growing best indeed, as all such plants will do, on the better soils, but suited to every kind from peat to the lighter soils and clay.

Of the species that have been mentioned, greatly the most important is the common oat, *Avena sativa*. Of this species there are innumerable sorts, produced by the effects of climate, soil, and

cultivation. These may be conveniently divided into three classes —the black, the dun or grey, and the white.

Those in which the corolla is very dark, are in the first class. The oats of this habit are awned, and the seeds are small. They are hardy, and ripen early, and it is this property which suits them for cultivation in cold and elevated districts. They are an inferior class of oats in their ordinary state, and should rarely be used where varieties more improved by climate and cultivation can be raised.

The next class of oats, the dun or grey, may be said to be intermediate between the black and the white. Some of them are awned and very worthless; but those that have been improved by culture and selection, are valued in the situations suited to them. Those that are chosen for seed should be plump, without awns, and with but a slight darkness of colour. The oats of this class are called red oats, sometimes dun, and sometimes blue oats.

The third class consists of those that are white, and the most improved of them are without awns. These are the least hardy kinds; but they are of the greatest weight to the bushel, and the most productive of meal.

In this class the Potato-oat is one which has possessed a considerable reputation in the districts where it has been cultivated. It is not so well suited to inferior soils as some of the other white and darker coloured kinds. It is less productive of straw than they, though the grain is more plump, weighs heavier, and yields a greater weight of meal. The hardier kinds of oats, however, are better suited to certain situations than the finer, just as the hardier red wheats are better suited to certain situations than the thin-chaffed and white varieties. The potato-oat was the discovery of accident, and the produce of a single plant. It has, in many cases, shewn a tendency to degenerate, by the husks becoming thicker and the body less plump, and by the partial appearance of awns.

Other minor varieties of the oat, which have had more or less

reputation, are the Late and Early Angus, the Blainslie white oat, the Poland oat, and others.

The varieties of the Angus oat have been much cultivated. They are hardy, of fair quality, and sufficiently productive. The Early Angus is the finer variety, and ripens about 10 days before the other.

The Blainslie oat, so named from a farm noted for producing it, used to be largely cultivated in the south-eastern counties of Scotland. It is somewhat small in the grain, but produces, on good soils, abundant crops of grain and straw. It is an early-ripening oat, but has now generally given place to other early-ripening varieties.

The Poland oat was long greatly valued. It ripens early, and produces an abundant crop of grain; but it is somewhat deficient in straw, and is supposed to be peculiarly liable to injury from shaking. This kind has been cultivated in England above 100 years, and, during that long period, has retained its characters.

Many other kinds could be named, as having been long cultivated in this country; but those enumerated will suffice for the purpose of example. Minor varieties of this nature may be multiplied to an unlimited degree, and we may constantly expect to see new ones obtained by accident, or by care bestowed in selection. A variety which has been lately extensively cultivated is the Hopetoun oat, derived from East-Lothian, and various others have been introduced into favour. It may be said in general, with respect to the principal kinds now in use, that the potato and other finer kinds of oat are the best suited for low lands, and the better class of soils; that the dun oats are suited to inferior soils, or to the more elevated grounds; and that on the soils lowest in the scale of fertility the improved black varieties may be used.

The oat has a wider range of soils than any of the other cerealia. It requires, too, less preparation of the soil by tillage and manures, and it bears more frequent repetition than wheat or barley.

The oat is generally sown after grass, and this is precisely the period in the rotation in which the oat should be sown. It grows

better upon old grass-land than any other crop, and should always be sown, accordingly, when land is broken up from grass of some years' standing. When land, indeed, is broken up from grass of one year, wheat, it has been seen, may be sown; but, in the majority of cases, the more suitable crop is oats.

When grass-land is to be ploughed for oats, this should be done in winter, or as soon in spring as the state of the weather, and the labours of the farm, will allow, so that it may, if possible, receive a little of the winter's frost to mellow it before the oats are sown. In the ordinary practice of the farm, the first operation after harvest is ploughing the stubble-land intended for fallow and fallow-crops, and then the grass-land which is intended for oats.

Oats may be sown after a summer-fallow. This is done when the soil and situation are less suited to wheat and barley than to oats. In this case, the fallow is ridged up before winter, and again receives a seed-furrow in spring, though frequently the oats are sown without the seed-furrow.

Oats are sown after pulse-crops, when the land is not in a fit state of preparation for wheat and barley, or when the soil and situation are unsuited to these crops. In this case, one ploughing is generally given in autumn, and sometimes a seed-furrow in spring.

Oats may be sown after turnips or other green crop, when they are more suited to the soil and situation than wheat and barley. In this case, the green crop being removed, the oats are sown after one ploughing.

Sometimes oats are sown after oats, or other corn-crop. This is a deviation from the general rules of good culture; but it is in some cases rendered necessary by the failure of grass-seeds, and other circumstances. In this case, the land may be ploughed once; but when grass-seeds are to be sown with the crop of oats, it is better that it receive a second tillage in spring.

When land is broken up from very old grass, good farmers sometimes take two crops of corn in succession. This is a deviation from the rules of the alternate husbandry. Circumstances

may render it expedient; but it is the exception, and not the rule, of general management.

Grass-seeds may be sown in spring with oats, in the same manner as with wheat and barley. But the land should in this case be prepared by previous fallow or green crop.

Oats are, for the most part, sown broadcast. When land is broken up from grass, it is not in so good a state for allowing the drill-machine to operate, and accordingly the more suitable method of sowing is broadcast. Exceptions to this may be required, when there is a great prevalence of annual weeds,—as of the wild radish and wild mustard; but the general rule for sowing oats is broadcast, and the sowing in rows the exception.

The period of sowing oats is generally from the beginning of March to the end of April. From the beginning to the middle of March is held to be the best period, when the weather and state of the ground will allow.

The quantity of seeds sown may be from 4 to 6 bushels to the acre. There are rarely sown more than 6 bushels, and there ought never to be sown less than 4.

Oats, from being sown after grass-land, are more apt to be overrun with thistles than the other kinds of grain; hence it is usual to weed this crop by going over it with the weeding instrument before referred to.

The reaping of oats is by the scythe or sickle, in the manner before explained. They should be allowed to ripen, but not to stand till they are dead-ripe. When ripe, they are to be taken sharp, as it is termed, by which means the chance of loss by winds at this critical period is lessened.

The produce of oats varies greatly with the nature of the soil and the mode of management. It is frequently calculated that 30 bushels to the acre may be the average in this country. In Scotland, where the culture of the oat is more attended to than in any other part of Europe, 60 bushels are held to be a good crop, below 30 an indifferent or bad one.

Oats vary in weight from 35 lb. to 48 lb. the bushel. The produce in flour is generally regarded as in the proportion of

about 8 to 14; that is, 14 lb. of grain give 8 lb. of meal, though the proportional quantity of meal increases as the oats are heavier, until it is one-half more.

The meal of the oat is used for bread; but though it is the food of a great part of the inhabitants of the north of Europe, it is inferior for this purpose to the flour of rye, and greatly inferior to that of wheat. It is used, however, in various simple preparations for food.

But the principal consumption of the oat is for the feeding of horses, to which purpose it is eminently adapted. In the practice of the farm, it is common to reserve the light corn for the feeding of the horses, and the heavier grain for seed and for sale.

The oat is employed also in malting and distillation; but for these purposes it is inferior to barley.

The straw of the oat is, in this country, more esteemed for provender than that of wheat, barley, and rye. It furnishes a great part of the food of wintering-cattle, as will afterwards be explained. It is given also to working-horses in place of hay in the early part of winter, when the work is not severe.

Oats are subject to considerable hazard of injury by the shaking of winds, as the grain approaches to its ripened state. In the early stages of its growth, too, it is subject to be attacked by several enemies, of which the principal is the wire-worm, which is the larva of a very small beetle, *Elater segetis*; and by the larvæ of several other insects, comprehended by farmers under the general term, Grub.

The diseases of the oat are not numerous. It is subject, though in a partial degree, to smut, occasioned by *Uredo segetum*.

5. Millet.

Under the term Millet are comprehended certain plants of different genera, which are cultivated for their seeds:—

1. Panicum miliaceum—Common Millet.
2. Setaria italica—Italian Setaria.
3. Setaria germanica—German Setaria.
4. Sorghum vulgare—Indian Millet.

Common millet grows several feet high, and is terminated by a large branched panicle hanging to one side. It is very prolific in seeds. These are small and smooth ; in some sorts brown, and in others yellow. The plant is cultivated extensively in Russia, in Italy, and in Germany. Its seeds, being divested of their outer covering, are often used in the manner of rice, and furnish a nourishing and grateful food. They are also made into bread, which, however, is not esteemed. They are used for the feeding of domestic fowls, for which they are well suited. The straw produced is bulky, and valued for provender.

The cultivation of common millet is not practised in this country. It is not with us a part of the food of the people ; while, with respect to the feeding of domestic fowls, we have so many resources in the waste of our cereal grains, that there is scarcely need of cultivating any plant expressly for the purpose. But more than this, millet is not well suited to the colder parts of Europe, and supplies of it can be obtained in unlimited abundance from the shores of the Mediterranean.

The Italian setaria, cultivated in the south of Europe, is only known to us in this country as a plant of the garden. It is too delicate for the northern parts of Europe : for even about Bourdeaux it is a precarious crop, suffering frequently from the effects of frost.

German setaria is cultivated in Hungary in fertile sub-humid soils. It is used in its green state, or as dried fodder for horses and oxen.

The Indian millet furnishes bread to the Arabians and other people of the East. The flour is known to the Arabs under the name of dourra ; and it is truly the bread-corn of Africa, being grown over all the parts of that vast continent. It is cultivated likewise in Italy, and the south of Germany ; and it was long ago introduced into Spain, it may be supposed by the Moors, if not at an earlier period still by the Carthaginians. It has been introduced also into the Islands of the West Indies, under the name of Guinea corn, and into the Southern United States of America.

This fine plant grows with a strong reedy stem, with broad

leaves like those of the maize, but smaller, and producing a large panicle. Its seeds are smooth and roundish, resembling those of the common millet, but larger. They are ground into flour, but the bread made of it is dark in colour and coarse. In Europe, the grain is chiefly used for feeding domestic fowls and pigeons, for which it is well suited.

This plant is the native of a warmer country, and demands a more genial climate, than we possess. With us it will scarcely even ripen its seeds, and frequently not even expand its flowers. Other species of *Sorghum* are likewise cultivated, but the same remark applies with more or less force to them all.

6. Maize.

Of the cultivated Maize, *Zea Maïs*, naturalists hold that there is but one species, yet the differences presented under different conditions of soil and climate are often as great as those which are held to distinguish species in the other cultivated gramina.

The maize has a wide range of temperature. In the western continent, it flourishes from about the 40° of southern to beyond the 45° of northern latitude. It is extensively produced in Africa, Asia, and the south of Europe. On all the shores of the Mediterranean,—Spain, Italy, and the countries of the Levant,—it supplies the food in most common use. The region of the maize in Europe seems to have been extending northwards. It is grown in France, Germany, and even in the Netherlands. The last, however, is somewhat beyond the true region of the maize, which requires the warmer summer of the south of Europe to bring it to its full perfection. The kinds best suited to the colder parts are the dwarf, some of which, even in the latitude of Paris, complete the circle of their vegetation in a period comparatively short.

The manner of cultivating the maize in the countries where it is produced, is generally rude and inartificial. The proper method of cultivating it is in rows at the distance from one another of from 3 to 4 feet. In this manner the plants can be tilled by the

horse and hand hoe in the most perfect manner, and the earth heaped up to the stems of the plant by the operation of the common plough. This heaping up of the earth tends to support the long stem and weighty ears. The plant, although it has a very fibrous root, does not penetrate deeply into the ground; but from the lower joints of the stem, it sends forth large roots, which partly serve the purpose of supporting it. During the growth of the plant, and even till the seeds are formed, the tilling may be continued, and the earth heaped up to the stem.

The maize is a plant which with difficulty bears the rigour of early spring. It is easily injured by frosts; and hence the necessity of adapting the period of sowing it to the peculiarity of the climate. The plant, like the other gramineæ, may be transplanted, and that, too, after it has attained a considerable size. In planting, therefore, it is well to have a provision of plants for the filling up of blanks.

A peculiarity in the manner of treating the plant is founded upon the circumstance of its being monœcious. The flowers bearing stamens are produced in a branched spike at the summit of the stem. The female flowers grow lower down on the stem. Upon these the pollen falls from the flowers above. As soon as the male flowers have performed their functions, by depositing their pollen on the organs below, they become no longer necessary, and they, accordingly, with all the elevated part of the stem which supports them, may be removed. This is familiarly termed topping; and the period of performing it is denoted by the state of forwardness of the plant. When the silk-like filaments of the female flowers are withered, and when, upon stripping off the husks, the grain is found to be somewhat hardened, then the tops and even the leaves may be removed without injury. These form a valuable deposite for the winter, and may be reserved for food for horses and oxen in spring.

The harvest-labours of the maize are altogether different from those of the other cerealia. The ears are stript from the stem by the hand, and carried directly to the barn-floor, to undergo the process of husking. The husks, consisting of a thick leafy cover-

ing which closely envelopes the ear, are then also stripped off, and the ears are deposited in some convenient place.

The next operation is that of separating the grain from the ear. This may be done by a machine, but it is generally done by scraping or rasping the ears upon a piece of iron fixed across a wooden vessel into which the grains are received.

The flour of the maize, on account of the deficiency of gluten, is greatly inferior to the flour of wheat for the making of bread. It is, however, a perfectly nutritious substance, and becomes palatable to those who are used to it. Its flour is converted into various preparations, and used extensively in the countries where it is produced. In America, the people of every condition eat the maize in its different states. The most delicate, perhaps, is when the ears are green, and the seeds simply roasted or boiled. In this state they are enjoyed by people of all ages throughout the United States.

The maize is a nourishing food for all domestic animals. It is suited to the feeding of the horse: hogs get speedily fat upon it, and poultry eagerly eat the hard grains.

The maize is thus a very valuable plant in all the countries in which it is produced. It is only, however, in the warmer parts of Europe, or in the countries which, like North America, have a hot summer, that the maize is calculated to take the place of the common cerealia.

7. Rice.

Rice has been known and cultivated from the earliest records of the human race, and is believed to furnish food to a greater number of human beings than any other of the cultivated gramineæ.

Of this plant there has usually been held to be but one species:—

Oryza sativa—Common Rice.

But there are subspecies or varieties, so greatly different in their habits and characters, that they may be rather perhaps regarded as specifically distinct. They may be all referred to two

general types,—the Common rice, so termed, and the Mountain rice, *oryza mutica* of many botanists, which differs from the other in its general aspect and habits. The Common rice grows from one to six feet in height, terminating in a panicle, the seeds of which are armed with long awns. It is cultivated in marshes, and, for a great part of its growth, is partially under water. The Mountain rice grows on mountains and dry soils. A plant of this class has been recently found growing high on the range of the Himalayan mountains.

The rice is spread over all the warmer regions of the Old World, and has been carried to the New, where it flourishes in great luxuriance. The Common rice is cultivated in the south of Europe, and the Mountain rice has lately been extended to the more northern parts of it,—to Westphalia, and even to the Low Countries. Rice seems to be a plant fitted, in a remarkable degree, to accommodate itself to different situations. It is a considerable period since it was introduced into the countries north of the Mediterranean,—Greece, Italy, and Spain. It is more recently that it has extended to Hungary and central Europe; but whatever be the power of acclimating of the rice, there is little reason to suppose that it will ever form any thing beyond an inconsiderable part of the cultivated gramineæ of Europe.

8. Canary-Grass, &c.

The cereal grasses that have been enumerated, afford the main part of the farinaceous food of mankind. Besides these, however, other grasses are cultivated, or used for their seeds, as—

1. Phalaris canariensis—Cultivated Canary-grass.
2. Poa fluitans—Floating Meadow-grass.
3. Digitaria sanguinalis—Hairy Cocksfoot, or Finger-grass.

Canary-grass is cultivated in a few parts of the south of England, and chiefly in the Isle of Thanet, for its seeds, which are given to the smaller birds. The plant is easily raised, but is of little economical importance.

Floating meadow-grass is a native plant tolerably productive of seeds, which are sweet and nourishing. They are collected in some parts of Germany, Poland, and other parts of Europe, and used as food; and they are brought to this country under the name of Manna. The plant is too aquatic in its habits to admit of extended cultivation,

Hairy Cocksfoot, or Finger-grass, is an annual plant, growing in sandy cultivated fields. In Poland and Lithuania it abounds by the roadsides, and its seeds, being collected and boiled with milk in the manner of rice, are said to be esteemed.

Many other grasses could be enumerated as yielding seeds of sufficient size to be used as food; but none of them can be regarded as fitting subjects of cultivation for their seeds. Canadian Rice, *Zizania aquatica,* which grows in vast abundance in the marshes of North America, and may be said to form the wild bread-corn of the wandering tribes of Indians, is too aquatic for cultivation, and requires a hotter summer than the higher latitudes of the old continent afford.

(2.) *LEGUMINOUS PLANTS.*

1. The Bean.

The bean is of the genus *Faba*, of which there is reckoned one species—

Faba vulgaris—Common Bean.

But great diversities, in the habit and aspect of the plant, have been produced by the effects of climate, soil, and culture.

Of the beans which form the subjects of cultivation in this country, there may be said to be, with respect to their uses, two general classes,—those which are cultivated in the fields, and are thence termed field-beans, and those which are cultivated in gardens, and so termed garden-beans. The former, too, are frequently termed grey beans, and the latter white beans.

Of the white or garden beans, the sorts are very numerous.

Those that may be here referred to as cultivated also in the fields, are the Mazagan-bean and the Long-podded.

The Mazagan-beans are regarded as the best of the early kinds at present in cultivation. They are said to be derived from Africa; and their habits change by their being cultivated in this country. They become larger, and do not ripen so soon as when first imported.

The Long-podded are of the middle size of garden-beans, and are very productive, the pods being long, and closely filled with seeds. Of the long-pods there are many varieties enumerated by gardeners.

These two sorts, though raised in the garden, are also cultivated partially in the fields, and they are reckoned to be the best of the garden kinds used for this purpose.

The kinds, however, the most important to the agriculturist, and forming the subjects of common cultivation in the fields, are the smaller and hardier kinds, termed field-beans. Of these, the principal are the horse-bean and the tick-bean. The former is the more hardy; the latter is generally regarded as of better quality, and more productive. The horse-bean grows more tall than the tick-bean, but it is not so productive of pods. The tick-bean contains many subordinate varieties, to which names are assigned, as the Flat-ticks or May-beans, the small or Essex-ticks, &c. To the field-beans in use may be added the Heligoland bean.

The bean, generally speaking, is suited to the clayey soils. The seeds may be buried deeply in the ground. In colder countries, they are generally sown in spring; but they may be sown previously to winter, and then the beans acquire the habit of later ripening, and are termed winter-beans. The manner of cultivating the bean is greatly influenced by climate; and the agriculturists of different countries learn to suit their practice to this circumstance.

The bean, from the habit of its growth, and the mode of culvation which it admits of, is a cleaning crop, and, in the rotation, is generally made preparatory to a corn-crop. It is regarded as

well suited to prepare the land for wheat or barley ; and ought, therefore, to precede one of these crops.

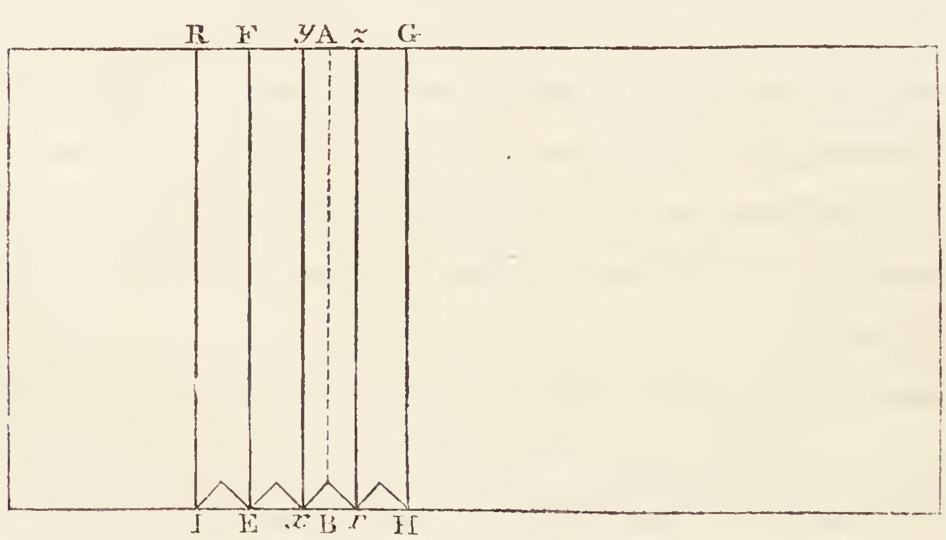
Beans may be sown on land broken up from grass, and will succeed perfectly well in such a case ; but oats are more generally suited to land broken up from grass ; and beans should rather follow a corn-crop.

When the bean is to be sown in spring after a corn-crop, the land should receive a deep ploughing before winter, generally in the direction of the former ridges, so as to keep the land dry. Sometimes, in the case of dry land, the ploughing may be across the ridges ; and then the plough, passing along the former water-furrows, is to form new water-furrows in the same place. In either case, care is to be taken to prevent the stagnating of water on any part of the surface.

As early in spring as the land is sufficiently dry to be worked, it is to be ploughed across the direction of the former ploughing. The land is now to be left to dry for a few days, and then it is to be harrowed, so that the surface may be levelled ; and then, with the common plough, the whole surface is to be formed into raised ridglets, or drills.

These drills are formed by a single furrow or turn of the plough in the following manner :—The plough, entering at the headland of the field, at x in the diagram below, draws the straight furrow $x\,y$ from side to side. Turning to the right at y, and entering at z, it draws the straight furrow $z\,r$, and thus forms the drill

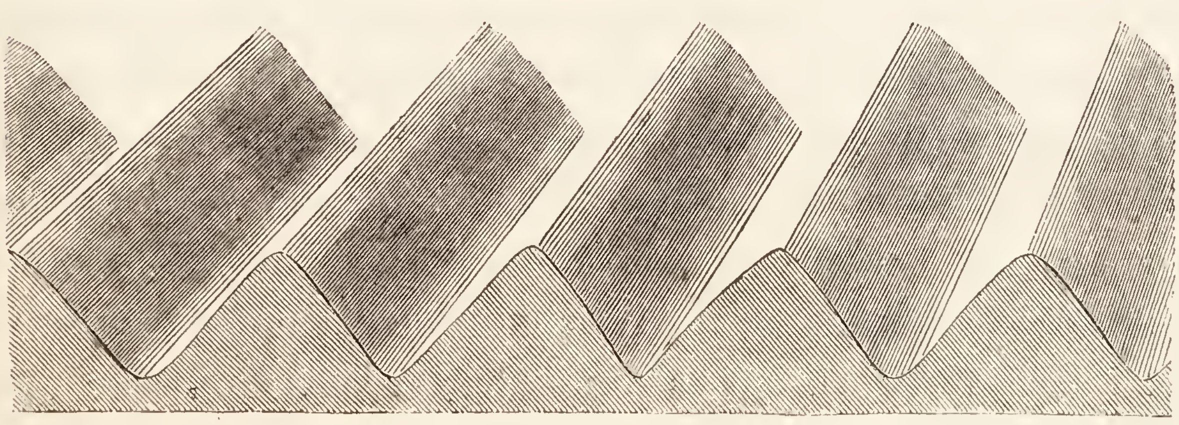
Fig. 161.



$x\,y\,z\,r$, of which the centre is AB; this first drill being necessarily formed by a double turn of the plough, while the others are formed by single turns; for the plough, then turning to the right and passing on to E, draws the straight furrow EF, and so forms a drill by a single turn. At F it turns to the right, and, passing on to G, draws the straight furrow GH, and so forms another drill; and then, passing to I, and drawing the furrow IR, forms another drill; and so on until it has formed a certain space into drills. Equal spaces being drilled in this manner, the whole field is passed over. The plough, it has been said, is to turn to the right, but it may be also turned to the left if more convenient; or, having formed a certain space into drills by being turned to the right, it may form an intermediate space into drills, by being turned to the left, on the same principle as was explained in the case of cross-ploughing. In place of forming the first drill by a double turn, in the manner described, the operation may be performed thus:—The plough passing from x to y, forms the drill $x\,y\,z\,r$ by a single turn. On arriving at y, the plough turns left about, and, returning by the same track, forms another drill $y\,x$ EF, also by a single turn; on arriving again at x, it turns to the left, and proceeding from r to z, forms the drill $r\,z$ GH; on arriving at z, it passes on to F, and, proceeding from F to E, forms the drill FEIR.

The drills thus formed should not be less than 27 inches from centre to centre. A transverse section of the land, when drilled, will appear thus:—

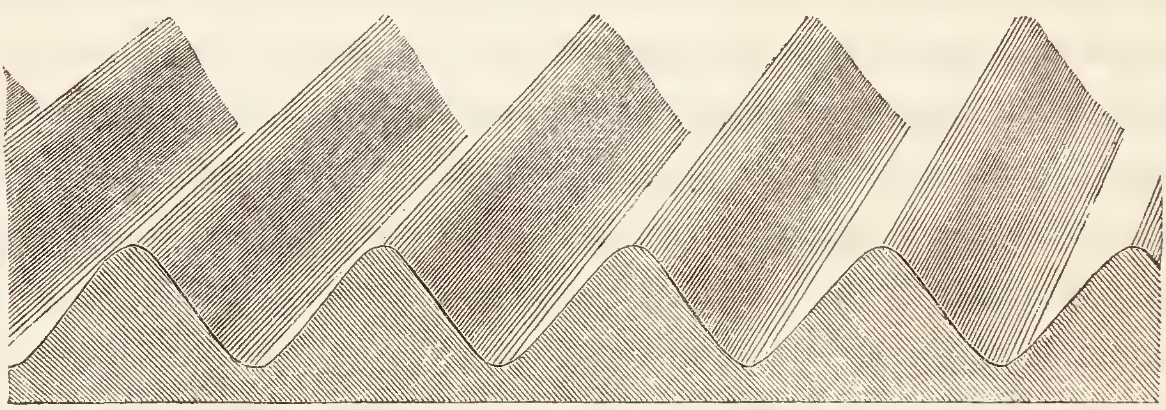
Fig. 162.



The land being thus ridged up, the seeds are to be sown by

the sowing-machine (Fig. 35), or better by the machine (Fig. 36), which sows three rows at once. The former is pushed forward by the workman, the latter is drawn by a horse. The seeds are thus sown in the hollows of the drills, and the plough passing along the centre of each drill, splits it into two, and so covers the seeds. The common plough performs this operation, or it may be performed by a double mould-board plough. A transverse section of the drills when split or divided will appear thus :—

Fig. 163.



In this manner, the seeds are well covered, sown in rows at the distance required, and prepared for the subsequent operations.

But the previous operations taking place at a very early period of the season, wet weather may intervene to prevent this species of tillage. In this case, in place of first ploughing the land, and then forming it into drills, it may be found necessary to give only one ploughing. The simple sowing-machine, pushed along by the hand, is to follow every third plough, or, in other words, to be pushed along every third furrow, depositing the seeds in the hollow. The succeeding furrow-slice covers the seeds, and thus they are deposited and covered in every third furrow throughout the field. By these means the seeds are sown in rows; and, supposing the width of each furrow-slice to be 9 inches, the distance in the rows of beans from one another will be 27 inches; or 30 inches supposing each furrow-slice to be 10 inches.

The latter method of sowing is less effectual than that by raised

drills, and therefore should not be resorted to, except when the state of the weather renders it necessary.

The running of a sowing-machine in every third furrow may seem to be a somewhat clumsy operation; and yet the loss of labour is extremely trifling. Some farmers, however, attach the sowing-machine to every third plough, fixing it between the handles in such a manner that it sows the seeds in the furrow which is just formed: the three ploughs following one another in succession, and the third sowing the seeds, these are deposited and covered in every third furrow.

Dung is often applied to the bean crop, especially when wheat is to succeed; and it may be applied at two periods. It may either be spread upon the stubble in autumn, or it may be applied at the same time at which the drills are formed.

In the first case, the dung being spread upon the stubble, is covered by the ploughing which is then given; and this is greatly the better practice. In the second case, the land being formed into drills, and the seeds sown in the manner described, the dung is to be carried to the rows in single-horse carts, the horse walking in the interval of every third or fifth drill. The dung is to be dragged out by the dung-drag (Fig. 80), from the cart behind into little heaps. Three or more young persons are to follow each cart, and to spread out the heaps regularly. The dung is in this manner spread over the seeds. The ridglets are then to be split in the manner before described, and in this way, the dung and seeds covered. Many prefer spreading the dung first, and then sowing the seeds upon it.

When no drills, however, are formed, and when the seeds are sown in every third furrow, then the dung, if it has not been applied in the preceding autumn, is merely spread upon the ground before the land is ploughed, and covered by the plough at the time of sowing.

Such is a simple method of performing the culture of the bean, which has been found to be efficient in parts of the country where, from the uncertainty of the climate, and the nature of the soil, the

culture of the bean is the most difficult. This system, then, of sowing the bean in rows and in drills, is susceptible of being everywhere practised, and from its efficiency and simplicity, deserves to be generally imitated.

In various parts of England, a more operose method is adopted of sowing the bean. The land is not ploughed until about Christmas, or as soon afterwards as possible; and upon the furrow-slice turned up, the seeds of the bean are planted by means of the dibble, in regular lines, at the distance from one another in the rows of two or three inches, and at the rate per acre of about two bushels. The practices, however, which prevail in different parts of England, both with respect to the method of sowing, the quantity of seeds used, and the general treatment of the plant, are very various.

The bean being a slowly-ripening plant, the period of sowing should be as early after the land can be prepared in spring as possible. The month of February should be selected, if circumstances will allow, and the sowing should not be later in any case than the month of March.

Beans may be sown previously to winter, though the practice is not suited to a very cold and humid climate. Where this system is adopted, the produce of beans sown before winter, or winter-beans, as they are called, must be selected, and those always of the hardy kinds. When the bean can be sown previously to the months of winter, it removes certain difficulties attending the present method of cultivating it, and hastens the harvest process, so often injuriously retarded in the case of cold countries.

The quantity of seeds sown must depend upon the nature of the soil and climate. In the north of England and Scotland, four bushels to the acre are not found to be too much; while in the parts of England where the climate is more favourable to the ripening of the bean, a much smaller quantity is used, and especially where the dibbling process is resorted to.

It is a frequent practice to mix a quantity of pease with beans, generally in the proportion of about half a bushel to the acre.

This increases the value of the fodder, and generally adds to the weight of the crop. But many farmers do not approve of any intermixture with the bean.

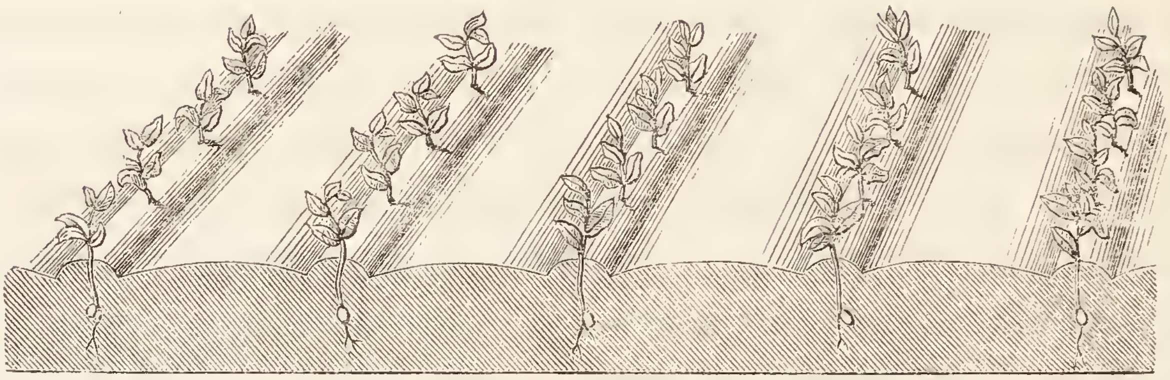
In about ten or twelve days after the beans have been sown, the land is to be well harrowed across. This process of harrowing should be resorted to in all cases of the bean culture, whether the beans are sown in drills or on a flat surface. It should be performed just before the beans appear above ground; or, if it cannot be then done, it may be delayed till after the plants have got a little above ground. This operation of harrowing destroys the weeds that may be springing up amongst the plants, or in the intervals of the row. It seems to be a very rude process, and yet it is never hurtful, but, as in all cases of stirring the soil, tends to promote the growth of the plants.

Immediately after this harrowing process, care must be taken to clear out all cross channels, so as to give free egress to surface-water; nothing being more destructive to a crop of beans at this stage of their growth, than to permit water to stagnate upon the field.

After the beans have made some growth, sooner or later, according to the state of the weather, the process of horse-hoeing is to commence.

The hoes employed for this purpose are either the small single-horse plough (Fig. 40), or the horse-hoe, with coulters (Fig. 41, or 43). In the first hoeing to be given to the plants, it is frequently better to employ the single-horse plough. The subsequent hoeings may be done by the horse-hoe. When the plough is used, the ploughman, driving his horse between the rows, makes a shallow furrow as near the rows of the plants as the plough can go without injuring them, laying the furrow-slice towards the centre of the interval. He then returns by the adjoining row, in the same manner, throwing the furrow-slice also towards the centre of the interval; and in this way the ground is tilled as near the rows of plants as the plough can go. A transverse section of the drills after this operation will appear thus:—

Fig. 164.



Immediately following the operation of the horse-hoe, the hand-hoers, each with a little hoe (Fig. 78), are set to work. Each hoer takes a row, and with the hoe cuts up any weeds that may have escaped the action of the hoeing instruments, or that may be found amongst the plants in the rows, using the hand, when necessary, to pull up weeds amongst the plants.

In about a fortnight after this, the horse-hoe again passes along the intervals, and again the hand-hoers follow, cutting or pulling up all the weeds that may have escaped the action of the horse-hoe.

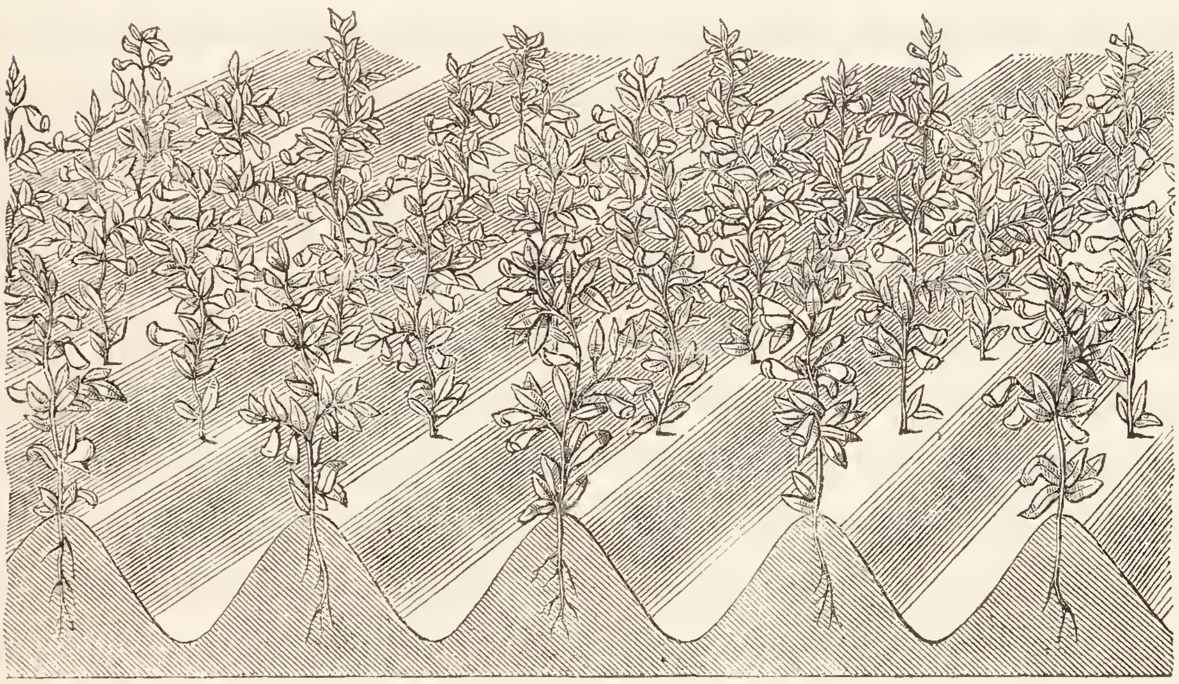
This will generally complete the hoeing process; but, if necessary, the hand-hoers are to be set to work a third time, so as effectually to clear the ground of all remaining weeds. A section of the ground after these operations will appear thus:—

Fig. 165.

Some time after the last hoeing, the double mould-board plough (Fig. 42) may be driven along the centre of the intervals, so as to lay up the earth as close to the rows of plants as possible. Many

farmers, however, omit this final ridging up of the land, either conceiving that it is unnecessary, or that it tends to interrupt the harvest process, by rendering the ground uneven. Yet this final ridging up makes a good conclusion to the process of culture. A section of the field after this operation will appear thus :—

Fig. 166.



The cleaning processes being performed, the plants grow without further care, and will generally cover all the surface, and prevent the growth of weeds during the remainder of the season.

A well managed bean-field cultivated in this manner will be like a garden. The land, in respect of cleanness, will be nothing short of the condition in which it would be after a summer-fallow, and the soil will be prepared for a crop of any of the cereal grasses.

The superiority of the practice of drilling over that of sowing broadcast is apparent. In the case of broadcast, a favourable season, and other circumstances, may cause as great a crop to be produced, but this will not be so upon an average of seasons, while all the advantages of the more perfect tillage of the ground will be lost.

In all cases of the row-culture, the system should be carried into full effect. The intervals between the rows of plants should never be made narrow, with the design of saving ground. All

experience shews that not only by the wider rows can the crop be more perfectly tilled, but that, in the great majority of cases, the crop will be more abundant.

In cold and humid countries, the harvest-management of the bean is peculiarly difficult, on account of its late period of ripening, and the large and succulent stems of the plant.

The bean should be suffered to ripen thoroughly, but not to become over-ripe. The period of ripening will be denoted by the skin of the seeds having acquired a yellowish leather-like appearance.

Beans may be cut by the scythe or by the sickle. When the sickle is used, the utmost care is to be taken that the plants be cut low, both on account of the value of the straw, and of the saving of such pods as may be growing near the bottom of the stem. The beans are to be formed into sheaves, by tying them with straw-ropes previously prepared, or, when pease are mixed with beans, by ropes formed of the stems of the pease twisted upon the spot at the time of reaping. The beans should be merely laid upon these ropes in the first place, and left for a few days to dry and wither, before they are bound into sheaves. Some lay down the beans, in the first place, in large handfuls, upon the ground, and allow them to remain there for a few days, before being collected and bound into sheaves. When the sheaves are bound, they are to be set up into double-rowed shocks, without any covering of head-sheaves.

The beans, when fully ready, are carried to the barn-yard, and formed into stacks like other crops.

They are thrashed and dressed in the manner described in the case of the cereal grains. From the largeness of the seeds, the process is a simple one, the lighter and broken grains being more easily separated from the heavier than in the lighter kinds of corn.

The produce of the bean is exceedingly various in this island. Forty bushels to the acre are regarded as a great crop ; 30 bushels are a satisfactory one, and probably the average produce of the kingdom does not amount to 25.

The grain of the bean is chiefly applied to the feeding of horses, though largely also to that of other animals, and chiefly of hogs, in which latter case it is usually manufactured into a coarse kind of meal. In the feeding of horses, it is common to mix a portion of beans with oats.

The straw of the bean is nutritious and wholesome. It is generally given to horses, and is reckoned little inferior to hay.

The bean is a plant very subject to diseases, and, in an especial manner, to injury from the attacks of several animals.

The most common disease of the bean is a species of rust, produced by parasitic plants of the mushroom family, growing upon it in the same manner as rust or mildew on wheat.

The animals that attack and feed upon the juices of the bean are certain aphides, the most common of which is of a bluish-black colour, and is popularly called the *collier*. In some seasons this creature is very destructive. It begins at the top of the plant and continues multiplying downwards. A remedy, which has been suggested and practised, is to cut off the top of the plants as soon as the aphides appear; and this may be a palliative if carefully performed.

2. The Pea.

Of the cultivated Pea there seems to be one species, comprehending our various cultivated kinds, whether grown in the garden or in the field, namely—

Pisum sativum—Cultivated Pea.

But botanists of high authority make two species, *Pisum arvense*, the Grey Pea, and *Pisum sativum*, the Cultivated Pea of the gardens.

The changes produced in this plant by the effects of climate, soil, and culture, are very great. Whether regarded as one or two species, pease, with respect to their uses, may be divided into two classes; the first, the field-pease of different colours, and

the second, the white or garden pease. The coloured kinds are those which generally form the subjects of cultivation in the fields; the white kinds are those which are grown in the garden, though several of the white kinds are also cultivated in the fields, and though some of the garden kinds are coloured.

The garden-pease are distinguished by their periods of ripening and other properties. New kinds of them are raised every year, and generally receive names from the persons who have first cultivated them, or the places where they have been grown. Their characters, however, are not permanent, and they degenerate, unless cultivated and selected with care.

The field kinds are distinguished by their habits of ripening. The early-ripening kinds admit of being sown late; the late-ripening kinds must be sown early. The common early-sown pease of the country are small and dark in their colour. The most hardy of these is generally termed the early grey pea. It is chiefly cultivated for the food of horses.

The later sown kinds of field-pease are larger in their size, and approach more in their characters to the garden-pease. The seeds are of various colours, blue, speckled, grey, and dun; and they have purple flowers, whereas the true garden kinds have generally white flowers.

The white kinds usually cultivated in the fields in this country are the Pearl, the Early Charlton or Golden Hotspur, and the common White or Suffolk. Of these the early charlton has been long esteemed as an early-ripening kind.

The pease of this class are largely cultivated in the north of Germany, in Poland, and all over the central and southern parts of Europe. In England they are raised to a considerable extent in Middlesex, Kent, Suffolk, and some other counties. But the principal cultivation of pease in this country is of the grey or field kinds.

Sometimes pease are cultivated to be used in their green state. There is no species of cultivation more profitable than this, where it can be adopted; for the pease being ready for use in the month of June, time is allowed for taking another crop, generally of tur-

nips, in the same season. The practice, however, of gathering pease in their green state, must necessarily be limited to the vicinity of great markets; and in most parts of the country it is the province of the gardener rather than of the agriculturist.

The general purpose in cultivating the pea is for its ripened seeds. When these are intended for boiling, the white kinds are used; when for the food of horses and other animals, the grey kinds are preferred. The method of cultivating either kind is the same. The circumstance to be chiefly attended to is the habit of ripening, which should determine the period of sowing.

The later-ripening kinds are sown in February or March; the earlier-ripening kinds in April, and sometimes so late as the beginning of May. But the more early all kinds of pease are sown the better.

The pea will grow on stiff soils as well as the bean; but it is more peculiarly adapted to the lighter class of soils, and in an especial degree to the calcareous.

The pea, like the bean, may succeed to any of the corn-crops; and, if properly tilled, it may, like the bean, be regarded as a cleaning-crop, and be succeeded by another corn-crop.

In many parts of England the pea is made to succeed to a crop of grass and clover, and it will grow well under such circumstances; but it has been before observed that a corn-crop may then be taken with benefit. It is generally better, then, that a crop of oats be taken, to which may succeed a crop of pease. This at least is the rule of practice, while the deviation from it which particular circumstances require may be regarded as the exception.

In the case of sowing pease on land broken up from grass, it is common in some parts of England to plant them by means of the dibble; and the most approved method of doing so is to put a row of holes upon each sod, so that the rows shall be at the distance from one another of about 9 inches. To allow of this the furrow-slices are laid very flat.

When the pea, however, is to follow a corn-crop, which is its proper place in the rotation, the land is ploughed before winter

as for beans, though there is not the same necessity for giving a very deep ploughing, as in the case of the bean, the root of the pea being more fibrous, and not striking down in the same degree into the soil.

When the land is ready to be worked in spring, it is to be cross-ploughed and well harrowed; and the pease are to be sown in rows, at the distance from one another of about 27 inches. Several methods of sowing may be adopted:—

1. The land after being pulverized by the cross-ploughing and harrowing, may be sown with the same kind of drill sowing-machine as is employed for the common grains.

2. The land may be formed into drills, as in the case of the bean; and the sowing-machines, Fig. 35 or 36, employed to sow the seeds. The land is next to be harrowed across, and thus the seeds are covered. It is not necessary to split the drills by the plough, as in the case of the bean. The harrow does the work equally well, covering the seeds of the pea to the depth of 2 inches, which is sufficient.

3. The seeds are sometimes covered by the plough, in which case they are sown in every third furrow. But the more frequent practice is to sow in every furrow, in which case the rows are only 9 or 10 inches asunder. This is a species of drilling certainly, but the great advantages of the drilling-system are lost when the intervals are thus narrow.

Of these methods of sowing the pease, the best, it is conceived, is that of sowing them on a flat surface by the common corn drill-machine, the orifices being adapted to the larger size of the seeds.

When either system of culture is practised, the quantity of seeds may be 3 bushels to the acre, or less.

When the plants are a few inches above ground, the horse-hoe (Fig. 41 or 43) is to pass along the intervals, the coulters being set to go as near the rows of plants as possible without injuring them.

Soon after, the hand-hoers, with the hoe (Fig. 78), follow and hoe up any weeds that are amongst the rows of plants, or

that may have escaped the action of the horse-hoe in the intervals.

Then, before the plants come into flower, the hand-hoers are again to pass along the rows, and hoe up all weeds as before. This completes the culture of the pea, which will now grow with great rapidity, and soon cover the intervals. Sometimes this growth is so considerable, that only one hoeing can be given; but in every case one horse-hoeing in the early stage of the plant, and one hand-hoeing, must be given.

When the intervals, however, are very narrow, as 8 or 9 inches, the common horse-hoe cannot be applied, and the hand-hoe alone is used. In some cases, indeed, particular kinds of horse-hoes with flat triangular shares are employed.

Early hoeing, in the case of this plant, should never be neglected. The effect is not only to repress the growth of weeds until the plant shall have acquired sufficient strength, but, as in all cases of tilling the ground about the stems, to give increased vigour to the growth of the plants. From the manner of growth of the pea, and from its stems quickly stretching over the intervals of the rows, the process of hoeing should be begun early, and assiduously prosecuted. After the first crop of weeds are destroyed, the plants themselves will grow and stifle all that may spring up during the subsequent period of their growth.

This is the system under which the pea may be beneficially cultivated. The land will thus be cleaned in an efficient manner, and prepared for any crops of grain that are to follow.

With the early-sown varieties of pease, it is common to sow a proportion of beans. This is a good practice, the tall and erect stems of the bean affording a support to the other, in the same manner as branches do in a garden. The proportion of beans may be equal to one-fourth part.

When manure is applied to the pea-crop, it should be laid on the ground, and covered by the plough before winter rather than in spring, fresh manure tending to cause this plant to run too much to straw. Lime is extremely beneficial in the case of this crop.

The ordinary method of harvest-management for the pea differs from that of the other kinds of grain mentioned. In some parts there is employed a tool called a pease-make, which is merely the half of an old scythe fixed in a handle. With this the pease are cut and rolled up into what are called wads or wisps, in which state they are left to dry. In other cases, old blunt hooks are employed, by pulling which towards the reaper, the plant is torn and broken at the surface rather than cut. The binders move in advance of the reapers, twisting the ropes for binding, and laying them down. The reapers, as they advance, throw the ropes behind them, and lay upon them the reaped pease in moderate bunches, their heads all in one direction. In this state they lie for a few days to wither, and are then tied in sheaves, but they are not set up in shocks. They are left upon the ground to dry, until they are ready to be carried home and stacked, and in the mean time they are to be turned once a-day, which is easily done by boys or girls passing along the rows with hooks in their hands, and hooking over the bunches.

The produce of the pea is very uncertain. Perhaps none of our cultivated crops presents such frequent failures. This arises partly from the diseases to which the plant is subject, and partly from the effects of late ripening and unfavourable weather. Thirty bushels per acre are held to be a good crop in most districts of this country. Perhaps the average of the kingdom should not be stated as much exceeding 20 bushels per acre.

Pease are greatly employed in this country for the feeding of horses, and for this purpose they are generally mixed with oats.

They form a very nutritious food, and should be given when dry, and in all cases bruised. They are also employed for the feeding of hogs, in the same manner as beans are, and they form a nutritive and fattening food. In this respect they are held to be superior to beans, which feeders imagine give a hardness to the pork. The meal, too, as well as that of beans, is made into a thick gruel, which, given with milk, forms an exceedingly good food for calves, after they have been fed for some time on milk.

But the pea is also used extensively for human food. In some

cases, it is ground into meal, and made into bread; which, however, though nutritious, is coarse and unpalatable. But the meal of the pea may be mixed, to a considerable extent, with the flour of wheat, without sensibly impairing the qualities of the latter. It is made also into bread with the flour and meal of barley.

But a common application of the produce of the pea is for soups, puddings, and other articles of domestic economy. In this way there is a great consumption of the pea in England, partly the produce of the country, and partly derived from the Continent. And a distinction is made between the different kinds of pease, derived from the difficulty or facility of boiling them. Those that moulder down are technically termed boilers, and this property seems to arise less from the particular variety, than from the nature of the soil on which they are produced. Calcareous matter, so favourable to the growth of the plant, tends, it is said, to give the quality of hardness to the seed. To fit the pea for its culinary preparations, the seeds are subjected to a species of grinding, by which the external covering is rubbed off.

The straw of this plant is greatly esteemed for fodder. It is not regarded as much inferior to hay, and it is given in place of hay to the working-cattle of the farm. Sheep, too, are fond of it, and it may be given to them in the cases where hay would otherwise be given.

The pea, like the bean, is subject to various diseases. It suffers like the bean from rust, and is rather more subject to injury from insects at the root. It is liable, too, like the bean, to the ravages of aphides. At a late period of its growth, great injury is sometimes sustained by a small beetle, *Bruchus granarius*, which deposits its eggs in the pods, and the larvæ of which destroy the seeds. Other species of beetles, in different countries, prove fatal to the pea; and in some countries to so great an extent has this taken place, as to put a stop to the cultivation of the plant. Assiduous tillage, and the avoiding of too frequent repetition of the crop, are the best preservatives against these evils.

3. The Lentil, Kidney-Bean, and Others.

Besides the bean and the pea, there are various plants of the rich natural family to which they belong, which produce seeds applicable to the purposes of human food.

In Spain, Italy, the south of Germany, and France, a greater consumption takes place of certain leguminous plants than is common in this country. These are used for haricots, soups, and other culinary preparations.

The principal plants of this class in cultivation are—

1. Ervum Lens—Common Lentil.
2. Ervum Ervilia—Bastard Lentil.
3. Ervum monanthos—One-flowered Lentil.
4. Lathyrus sativus—Cultivated Lathyrus.
5. Cicer arietinum—Chick-pea.
6. Phaseolus vulgaris—Common Kidney-bean.
7. Lupinus albus—White Lupine.

The Common Lentil, *Ervum Lens,* is familiar to us as a plant of the garden. There are several varieties of it, distinguished by the colour of their seeds, the greater or smaller growth of their stems, and the earliness of their period of ripening. The principal distinction is founded upon the colour of their seeds, in which respect they are divided into the brown and the yellow.

The species *Ervum Ervilia* is a native of the south of Europe. It is distinguished from the last in its botanical characters, but not in its uses.

Ervum monanthos, One-flowered Lentil, grows with more luxuriance than the last, and in its habits resembles the tare.

Lentils have been cultivated from the earliest times. They are greatly used over all the countries of the East, and, as has been said, in various parts of Europe. They were at one time more cultivated in England than now, but have generally given place to the bean and the pea, the comparatively small quantity of them which we consume being either raised in gardens, or imported from other countries.

Lentils require a somewhat light soil and warmth. They are greatly less productive of straw than the pea and the bean, and the produce of their grain is also comparatively small. Unless, then, there existed a sufficient demand and enhanced price for their seeds, there could be no benefit in introducing them into the field-culture of this country. They can always be obtained in the quantity required from countries better suited to produce them, and where the cost of labour is less.

Lathyrus sativus, Cultivated Lathyrus, is also sometimes termed Lentil. The seeds of this plant, when consumed in great quantities, possess the remarkable property of producing a paralysis or rigidity of the limbs, in the case of horses, hogs, and other animals fed largely upon them. They are, however, used extensively as food in Spain, the south of France, and other parts of Europe ; and are much esteemed for fattening various animals. The plant is of easy growth, and could be readily cultivated ; but it does not appear to possess properties to entitle it to supersede the common leguminous plants of our fields.

The Chick-pea, *Cicer arietinum*, grows naturally in the south of Europe. It is a beautiful plant with a very branched stem, and distinguished by its turgid legumes, and the peculiar form of its seeds. It is too delicate a plant for field-culture, and degenerates when raised in the colder parts of Europe. It is one of the various leguminosæ cultivated in India under the name of *chunna*, more commonly called by Europeans *gram*.

The Kidney-bean is another plant cultivated for its seeds. Though said to be a native of the East, it has been long familiar in the gardens of this country. In the southern countries of Europe, in Switzerland, Germany, and France, it is cultivated in the fields, and is very productive of seeds. It furnishes a nutritive and delicate food used in soups and haricots. Various species of it grow abundantly in America, and there form an article of cultivation for food.

Some species and varieties have tendrils and climb ; others are without tendrils. The most commonly cultivated species in Europe

is the common kidney-bean, *Phaseolus vulgaris*, of which there are several minor varieties.

The legumes of this class are more used in Catholic than in Protestant countries. This doubtless, in part, results from the abstinence from animal food on certain days, when the more nourishing kinds of vegetables are resorted to. And there is no class of seeds which form so good a substitute for animal food as the legumes. As a substitute for farinaceous food, indeed, there is the potato, which surpasses them all ; but still it were to be wished that the cottagers of this country were taught to vary their repasts with those simple and delicate preparations which are familiar to the labourers of some other countries. The different species of the kidney-bean, indeed, are not with us suited to extensive field-culture. But they may be raised in the garden, or chiefly obtained from other countries, while our fields are devoted to the production of plants congenial to the climate, and fitted to the general purposes of the farm.

The Lupine is another plant whose seeds are used for food, but they are coarse and bitter. The white lupine, *Lupinus albus*, is the species most frequently cultivated for this purpose. The lupines are known to us in this country as garden-flowers. In Italy, and other parts of the south of Europe, they are cultivated in the fields ; and a practice derived from the Roman husbandman is still pursued, that of ploughing them down, when in flower, for manuring the ground.

Others of the Leguminosæ might be enumerated, as forming, or calculated to form, the subjects of cultivation for their seeds ; but the bean and the pea, from their productiveness, and the large growth of their stems, are calculated, beyond all the others, to retain their place in the field-culture of northern Europe.

(3.) *BUCKWHEAT.*

This plant is cultivated for the farina of its seeds. It belongs to a family, the *Polygoneæ*, or Dock tribe, which is known to farmers as affording a class of common weeds.

Of the genus *Polygonum*, there are two species cultivated in Europe for their seeds,—

1. Polygonum Fagopyrum—Common Buckwheat.
2. Polygonum tataricum—Tartarian Buckwheat.

The first is the species commonly cultivated. The latter is of larger growth, and it is said to be more hardy, but it is less productive of seeds than the common buckwheat. A third species is cultivated in China and Chinese Tartary, *Polygonum emarginatum*, Notch-seeded buckwheat, which resembles the common buckwheat in its habits of growth. All these species are annual.

Common buckwheat bears white flowers tinged with red. Its stem is full of knots, and rises to the height of 2 feet or more. The plant is of rapid growth, continues to flower long, and bears at the same time flowers and ripened seeds.

Buckwheat is cultivated extensively in some countries. In China and other countries of the East it is used as bread-corn. It is produced for the same purpose in most countries of Europe, as well as for the feeding of horses, hogs, and fowls. In Germany and Poland, the seeds are used for broths, gruels, and other purposes, In Russia, they form a great part of the food of the inhabitants. In Spain, Italy, and the south of France, they are also an object of extensive cultivation. The Italian farmers cultivate this plant, as well as the species *tataricum*, esteeming the latter, in some cases, as ripening more early. Buckwheat was cultivated at a very remote period in England, but it has now gone much into disuse. The buckwheat is a plant very generally diffused, owing, in part, it may be believed, to the little labour required in cultivating it; to the short period in which it completes

its growth; and the facility with which it may be produced, even on the poorest soils.

The soils suited to it are the lighter kinds. It should not be sown earlier than the beginning of May, or rather the middle of May, as the young plants are apt to suffer from frost. But as it grows with great quickness, it may be sown at any time till Midsummer.

The land should be prepared for it precisely as for pease, and the seeds may be sown broadcast, at the rate of from 1 to 1½ bushel to the acre. It requires no further attention after being sown, than guarding it against the depredations of birds, to which it is very subject. It may be cut by the scythe; and its subsequent management is similar to that of the other grains.

Its produce may be reckoned from 25 to 30 bushels per acre, though this varies greatly under different states of soil and culture. It is a peculiarity of the plant that it does not ripen all its seeds at the same time, so that while a part of the plant is bearing flowers, another is ripening seeds. It must be reaped, therefore, before a great part of its seeds can be matured.

The seeds of the buckwheat may be given advantageously to horses, to poultry, and to hogs. The external part of them being rubbed off by a coarse grinding, they may be used for human food, like rice: they may be also converted into flour: and, in short, there is no purpose for which the grain of the cereal grasses can be used, to which the seeds of buckwheat may not be applied. But though the flour is white and wholesome, it is comparatively deficient in gluten, and so does not undergo the panary fermentation like wheat; for which reason it is generally made into a kind of cakes. Another of the purposes to which the seeds of the plant may be applied is distillation.

The stem of buckwheat when green is nourishing, but when dried it is hard, and not very readily eaten by animals. This, and the little comparative quantity of fodder produced, are the principal objections to the extension of the culture of buckwheat in England; and yet, from the facility with which the plant may be grown, and this on soils low in the scale of fertility, its cultiva-

tion might, in some cases, be attended with advantage. In the Netherlands it forms a regular part of the rotation, and is sown on all soils where other grains cannot be prepared in time. To the settlers in colonies, it affords a useful resource.

One of the purposes to which buckwheat has been applied from time immemorial, and for which, from the quickness with which it grows, it seems well adapted, is the ploughing of it down green as a manure for the land. Farmers who have made trial of this practice speak favourably of its effects: and cases may doubtless be conceived where it may be beneficially adopted. But, generally, where a good system of agriculture is established, and where a proper combination of the practice of tillage and feeding live-stock exists, a green crop, when raised, will be more advantageously applied to the feeding of animals in the first place, the manure which the consumption of it produces being then applied to the ground.

2. Plants Cultivated for their Roots, Tubers, and Leaves.

1. The Turnip.

Of the genus *Brassica*, or Cabbage, the species chiefly interesting to the farmer, as the subjects of cultivation, are—

1. Brassica Rapa—Common Turnip.
2. Brassica campestris—Wild Navew.
3. Brassica Napus—Rape or Cole.
4. Brassica præcox—Early Cole.
5. Brassica oleracea—Cabbage.

These species may be cultivated nearly in the same manner. But they may produce small fusiform roots, when they are cultivated for their leaves,—or for their seeds, which yield oils; or they may produce large esculent roots, when they are cultivated chiefly for their roots.

The varieties producing esculent roots are the following :—

1. Brassica Rapa—Common Turnip.
2. Brassica Campestris Napo Brassica—Swedish Turnip.
3. Brassica Napus esculenta—Turnip-rooted Cole.
4. Brassica oleracea caulo-rapa—Turnip-stemmed Cabbage, or Kohl-rabi.

Those which are cultivated in the fields of this country under the common term turnips, are—

1. The Common Turnip.
2. An intermediate class, which are probably hybridal varieties between Brassica Rapa and other species.
3. The Swedish Turnip.

The common turnip has numerous sorts, distinguished by the size and form of the roots, the time of ripening, and other properties. This plant has, like the others of the genus, two periods in its growth. In the first, the leaves rise directly from the root, and are large, rough, and jagged. In the second period, or that of its flowering, which is generally in the second season of its growth, it sends forth a stem, 4, 5, or 6 feet in height, with smooth-pointed leaves, entirely different from its first or root leaves.

The minor varieties produced by the effects of climate, soil, and cultivation, are very numerous, and have everywhere local terms attached to them. For the purposes of the agriculturist they may be divided into three classes, distinguished by their form :—1. The round or globular; 2. The depressed; and 3. The

Fig. 167.

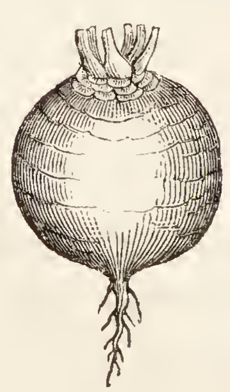


Fig. 168.

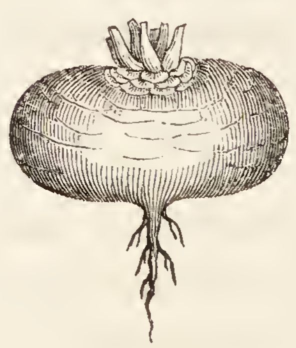


Fig. 169.

fusiform. These may be considered as types, to which the differ-

ent cultivated kinds more or less approach. Fig. 167 represents the round or globular kind, commonly termed the globe-turnip; Fig. 168, the depressed, frequently termed the Norfolk-turnip; and Fig. 169, the fusiform, frequently called the tankard-turnip.

They are further distinguished by the colour of the portion of the root which grows above ground. This may be white, green, or red; and the distinction is of some practical importance, because those of the white colour are regarded as the most palatable to animals, while the others are more hardy but less esteemed as food. These colours pass by imperceptible gradations the one into the other, but, generally, they are readily enough distinguished for the purposes of the farmer.

The turnips of the next class are distinguished from these by the root being yellow internally, and externally also under the surface of the ground. They have the leaves of the common turnip, and the habit and character of the *Brassica campestris* and *Brassica Napus*, and may be supposed to be hybridal varieties, formed between the common turnip and these species. The turnips of this class are hardy and nutritious, and resist well the winter frosts. They are distinguished from one another by the colour of the root above ground, which is sometimes dark purple, and sometimes green.

The last species is the Swedish turnip, as it is usually called. The substance of these turnips is hard and nutritious. They resist well the severities of the weather; and, retaining their juices and nutritive properties till a late period in spring, they are highly valued as a resource for live-stock at that season. The leaves of the Swedish turnip are less acrid than those of the common turnip, and may be used for human food in place of cabbage.

The Swedish turnip is cultivated in the same manner as the common and yellow turnips, but it is generally sown several weeks earlier, on account of the comparative slowness of its growth. It is more difficult to be raised than the common turnip, requires a larger quantity of manure, and should be sown on a good soil. It

has a property which the common turnip has not, that of bearing to be transplanted when young, so that when blanks appear in a field, the spaces may be filled up by transplanting.

In the common management of the farm, the Swedish turnips are first sown, the next in order are the yellow, and then the common.

The soils suited to the turnip are those of the lighter kind. The proper place in the rotation is immediately succeeding a corn-crop, and preceding another corn-crop.

The land intended for the turnip, as for all other green or fallow crops, is to be ploughed by a deep furrow in autumn, after the preceding crop of corn has been removed. The land is to be ploughed lengthwise, in the direction of the former ridges, by being cast or cloven, with open or close furrows, as the nature of the land may require; and care must be taken that no water shall stagnate upon the surface.

In the following spring, when the crops of corn are sown, and the potatoes planted, and when the ground is sufficiently dry, the tillage of the turnip-land is resumed. The chief period of the preparation of it is in the month of May and beginning of June.

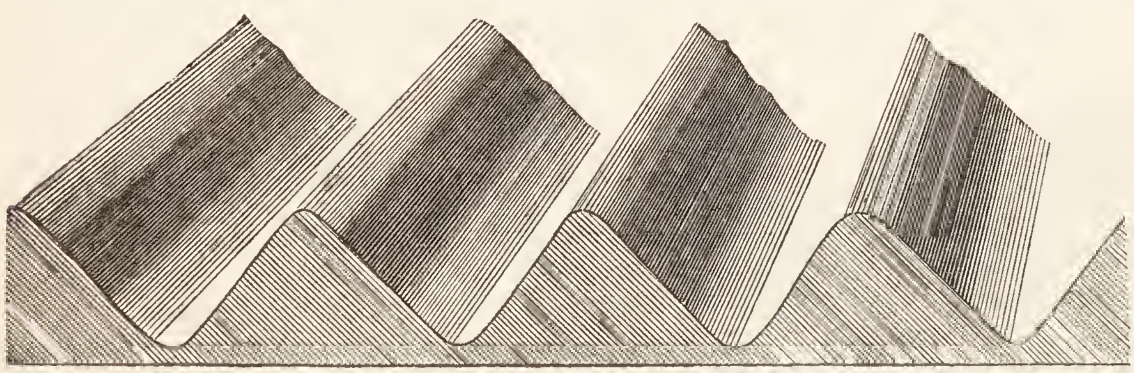
The first ploughing is to be given across, and the ground is to be repeatedly harrowed by double turns of the harrow in various directions. This is for the purpose of pulverizing the ground, and of dragging to the surface and disengaging the roots of weeds below ground. To assist in this operation, the roller is also to be employed when necessary; and the grubber is a useful subsidiary to the harrow and the plough. The roots of the plants disengaged are then to be gathered with care, and carried to a heap, to be mixed with quicklime and other substances, to form a compost. At the same time, loose stones and other obstacles to tillage may be removed.

The land is immediately afterwards to be ploughed in a direction traversing the last ploughing; and the same process of harrowing, rolling, and collecting the disengaged weeds, is to be repeated. The land is once more ploughed, and again the same operations are resorted to; after which the land is generally in a

fit condition to be formed into drills. Should this not be so, the operations of ploughing, harrowing, and gathering of weeds, are to be repeated, and this until the ground is cleared of injurious roots, and reduced to a friable state.

After this preparation, the land is to be formed into drills. This may be done by single-bout ridgelets, precisely in the manner described for the bean. The width of these drills, and consequently the distance from centre to centre, may be from 27 to 30 inches, which is necessary to allow the intervals to be tilled by the horse-hoe, and to admit of a sufficient circulation of air between the rows. A transverse section of the drills will appear thus—

Fig. 170.



The manure chiefly applied to this crop, in the ordinary course of management, is farm-yard dung. This requires to be well prepared. It is conveniently carried out, as was formerly explained, to the field, and laid in one or more large heaps. It is necessary to turn it over once, or oftener, in order that it may undergo the necessary degree of fermentation.

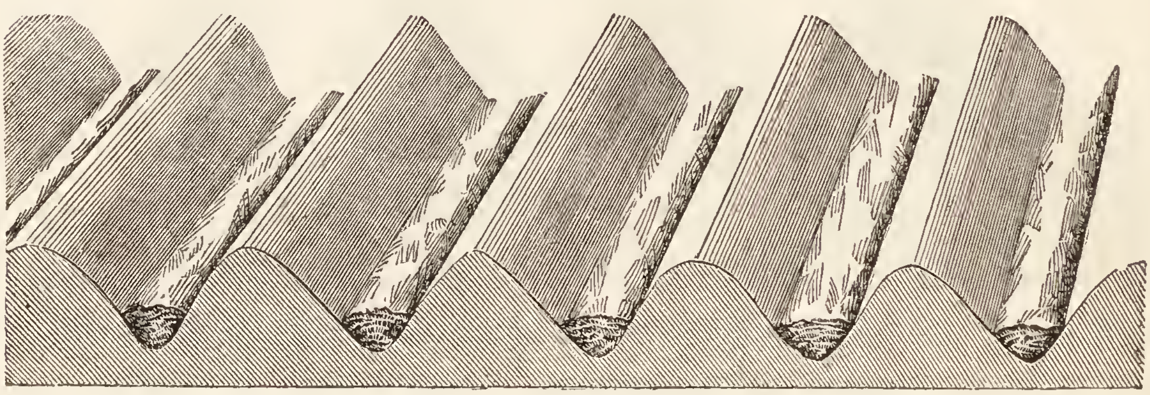
When the drills are thus formed, the dung is to be carried forward to them in single-horse carts. The driver directs the horse along the interval of a drill, and consequently each wheel of the cart will be in the interval adjoining. As the cart moves along, the workman pulls out the dung into little heaps, by means of the dung-drag (Fig. 80), and thus the dung is laid in heaps in the hollow of each third drill, at the distance from one another of 7 or 8 feet. For the economy of labour in this process, one or more persons are at the dung-heaps to fill, one person drives

the loaded carts to the drills and brings back the empty ones, and one person at the drills drags out the dung in the manner described.

Following the carts are persons, generally females or lads, with light three-pronged forks (Fig. 73), to spread out the dung from the little heaps regularly along the hollow of each drill. Four persons should be employed for every three drills, the duty of one of them being to go before and distribute the dung lying in the centre drill between it and each of the adjoining ones; while the three others, taking each a drill, spread the dung regularly along the hollows.

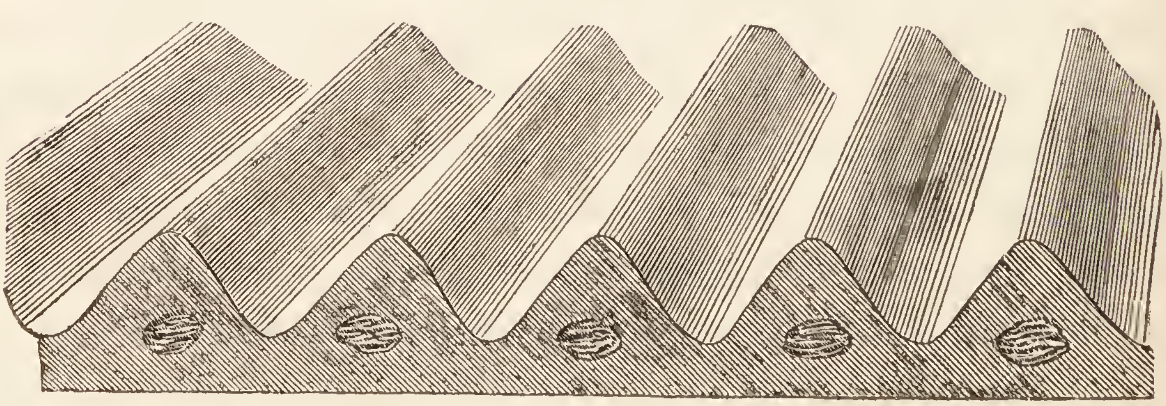
A cross section of the drills with the dung deposited in the intervals will appear thus :—

Fig. 171.



The dung being spread in this manner is immediately covered by the common plough, which, passing down the middle of each drill, splits it into two, so that a new drill is formed, whose top is immediately above the former hollow of the old drill, thus—

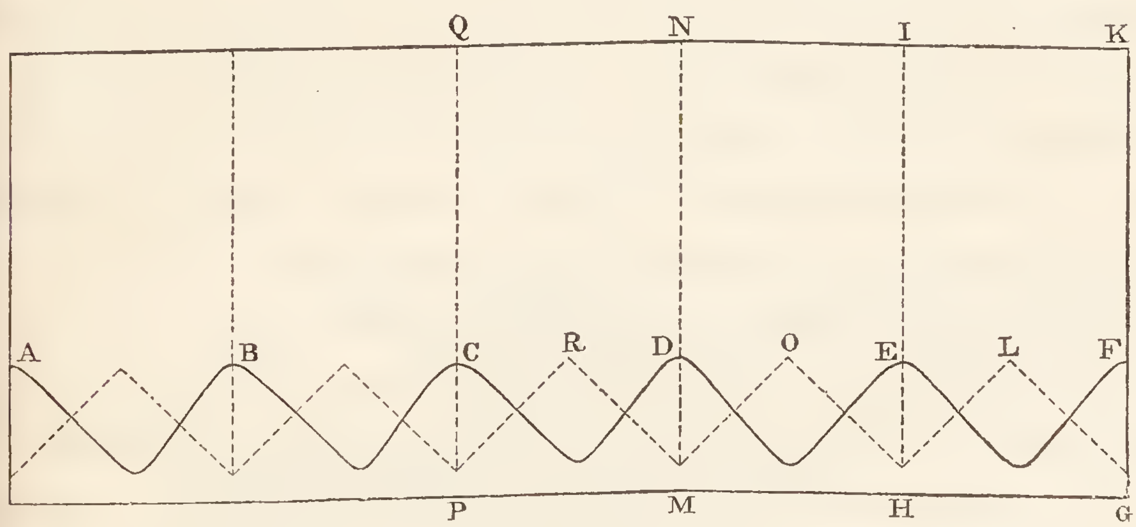
Fig. 172.



The operation of splitting the drills is performed by the common plough as follows:—

A double mould-board plough, by passing along the centre of each drill, would simply perform this operation, It is, however, more frequently done by means of the common plough in the following manner. In Fig. 173, let ABCDEF represent the apices of the old drills; let the plough be supposed driven in the direction from H to I, that is just along the centre of the drill, until it arrives at the headland at I; let it then turn to the right, and entering at K, the centre of the next drill, pass along the centre of the drill in the direction KG. This will form the first drill, of which the apex is L. Let the plough then turn to the right, and proceed by the centre of the next drill MN. Let it then turn to the right, and proceed from I to H. In this manner the drill of which the apex is O, will have been formed, and

Fig. 173.



this, it will be observed, by two bouts of the plough, first from M to N, and then from I to H. It is thus a double-bout drill. Let the plough, in like manner, turn from H to P, and proceed along the centre of the next drill in the direction PQ. Let it then return by NM, and so form the drill of which the apex is R. By proceeding in this manner throughout the field, each of the new drills covering the dung will be formed, appearing in a transverse section as before represented.

The dung is now completely covered, and a new drill for the

reception of the seeds at once formed. The double mould-board plough would perform this operation by one turn, but the common plough does it more completely by two turns.

Instead of depositing the dung in the manner described, it is sometimes laid upon the stubble after harvest, and is then covered by the first ploughing given. This, however, infers that a supply of manure remains upon the farm from the previous winter, or that it has been obtained elsewhere. The most economical employment, however, of manure made upon the farm, is in the spring immediately succeeding the winter in which it has been produced.

As liberal an expenditure of manure as can be afforded is always to be made in the case of the turnip-crop, the goodness of which will much depend upon the fertility which is communicated to the soil. But, in the common management of farms remote from the means of procuring external supplies, and where turnips are cultivated on the great scale, it is necessary to economise this valuable substance; and 10 or 12 tons per acre are considered to be the ordinary manuring on a regular turnip-farm.

Sometimes lime is applied to the turnip-crop, together with dung. This may be done by laying the lime upon the stubble after harvest, or by spreading it upon the ground, and harrowing it well previously to the forming of the drills.

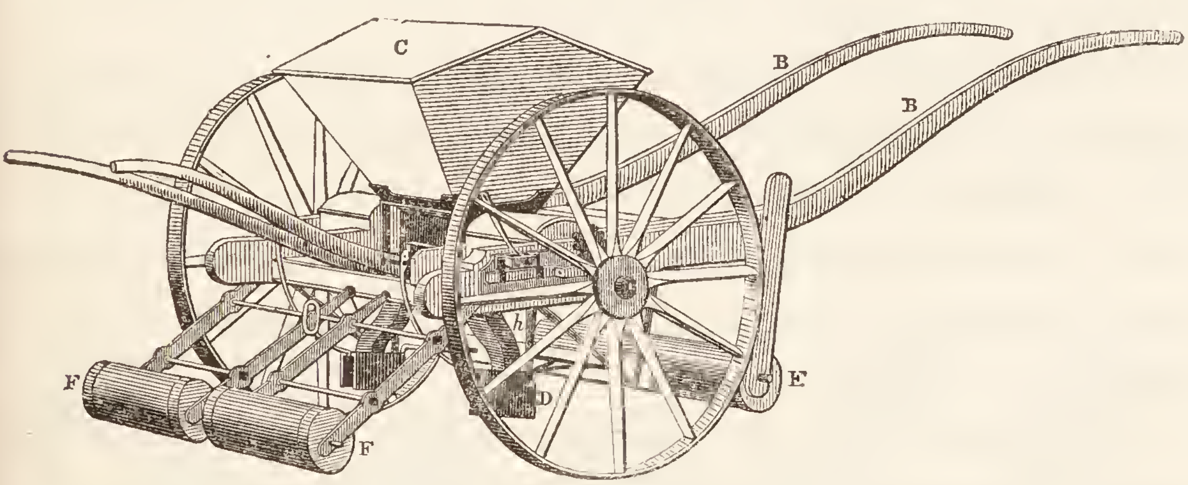
Street-dung is a good manure for turnips. Sea-weed, too, is used; and ashes generally produce a good effect, by causing the seeds to vegetate quickly, though their fertilizing effects are not usually of a permanent nature, and they are not so much esteemed as farm-yard dung.

Bruised bones have been employed with the best effects for the manuring of turnips, and are regarded as an important subsidiary to the other manures upon a turnip-farm. They may be applied in two ways, either by being spread in the hollow of the drills, and covered in the same manner as dung, or by being sown at the same time with the seeds, by means of an apparatus attached to the sowing-machine. Rape-dust may also be applied to the turnip-crop. It is usually deposited in the ground at the same time as

the seeds, by means of an apparatus similar to that employed in sowing bruised bones. When the manures are sown, the drills are not reversed, as in the case of the application of dung, but made at once in their most perfect form by a double bout of the plough.

The apparatus employed for depositing the manure is variously constructed. It may consist of a large box placed upon the framework of the sowing-machine. Moving in the lower part of this box is a spindle, with teeth or pinions upon it. These teeth, working amongst the bruised manure, cause it to fall through apertures at the bottom of the box, as in the case of the broadcast sowing-machine. The bruised manure falling into funnels, is conveyed to the ground just before the tubes which convey the seeds of the turnips to the ground, and in this manner both are sown at the same time. In the following figure, C is the box for containing the bone-dust, *h* one of the funnels, D one of the hollow coulters to which the funnel and tube for conveying the seeds are carried, BB are the shafts, FF light rollers for covering the seeds and bone-dust, and E the roller for flattening the drills.

Fig. 174.

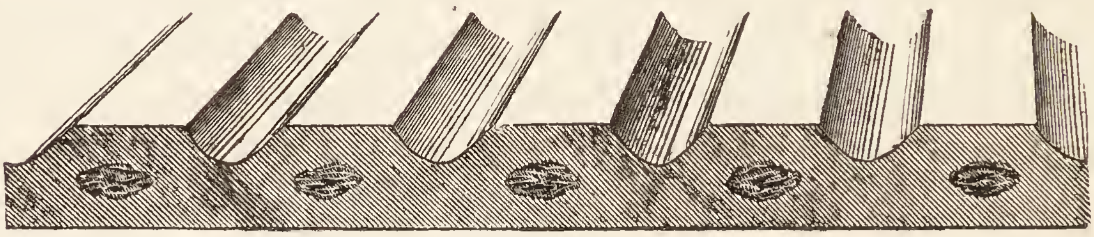


But reverting to the case of manuring with dung, which is the most frequent in practice: the dung, it has been said, having been spread, is covered, and new drills are formed, which are now ready for the reception of the seeds.

The seeds are sown by the turnip-drill (Fig. 38 or 39), which is drawn by one horse, the horse walking in the hollow of the drills,

and the workman who guides it holding the handles of the machine. By this operation, the drills are compressed by the roller in front of the coulters formerly represented. A transverse section of the drills will now appear thus :

Fig. 175.



The several operations of forming the drills, of spreading the dung, of covering it by the plough, and of sowing the seeds, are to be carried on in close succession. The dung is to be immediately covered, so that none of it may be lost by evaporation ; and to promote the early vegetation of the seeds, they are to be sown while the earth is newly turned up and moist.

The seeds of turnips may be sown upon a flat surface in rows, as well as upon the raised drills here described. But in the parts of this country where the turnip-culture is the most extensively and perfectly executed, the system of drills is preferred for the following reasons :—

1*st*, The manure can be more readily covered, and by being applied close to the roots of the plants, a smaller quantity will suffice to produce a given effect.

2*d*, The land can be kept more dry, and crops, accordingly, raised upon land so wet as otherwise to be incapable of yielding returns of any value.

But whether the method of sowing in rows upon a flat or drilled surface be adopted, either is far superior to the practice of sowing broadcast.

By sowing in rows, the plants can be more cheaply and quickly hand-hoed, the process being so simple as to be taught to young persons in a few hours ; whereas, when the plants are not regularly disposed in rows, considerable experience and time are required; and what is of greater importance still, the land under

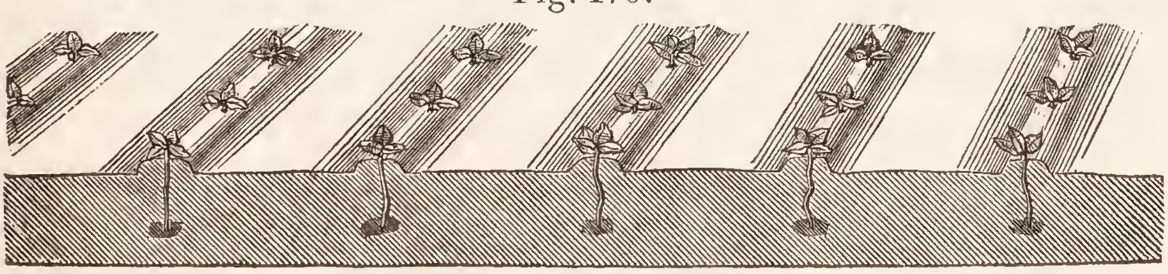
the one system can be more thoroughly hoed and cleaned during the growth of the plants than under the other.

The quantity of seeds sown may be 2 lb. to the acre. It is not proper to make the quantity excessive, but a sufficient number of seeds must be sown to provide against the loss of plants from the attacks of insects, and from other contingencies.

In the climate of the north of England and Scotland, the period of sowing is generally from the first to the end of June, though it is sometimes continued till the middle of July. The turnips sown after the latter of these periods seldom attain to a proper size, and when sown earlier than the first of June they are apt to shoot forth their flowering stem before winter, by which the nutritive juices of the root are exhausted. The best period of sowing, under the condition of climate supposed, is from the beginning to the middle of June; but in different countries the period of sowing must be suited to the warmth of the climate and quickness of vegetation.

When the plants have assumed what is termed the rough leaf, and are about two inches in height, the process of hoeing is to commence. The first hoeing may be performed by the small plough (Fig. 40) drawn by one horse, going and returning along the interval of each drill, and cutting off shallow slices of earth as near to the turnips as possible. Or the same operation may be more conveniently performed by the hoes with coulters (Fig. 41 or 43), passing along each interval once. A section of the ground appears thus:

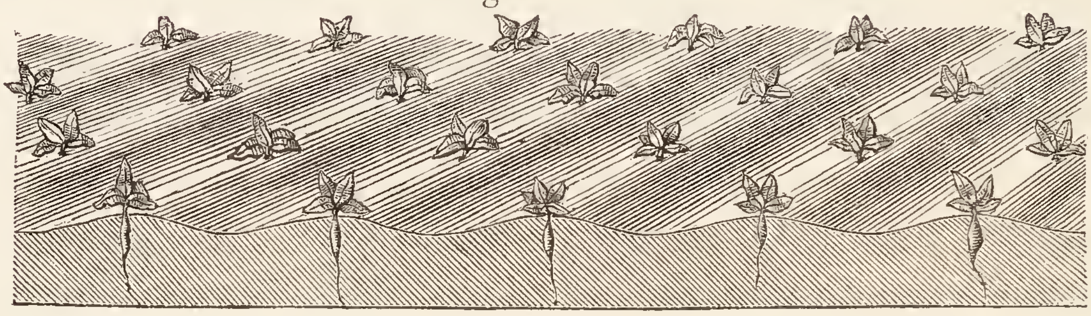
Fig. 176.



After this operation the plants are hoed to the proper distance from one another by the hand-hoers, with the hoe (Fig. 78). Each takes a drill, and, standing facing the rows, by an alternate pushing and drawing of the hoe from and towards him, thins the

turnips, leaving them standing singly at the distance from one another of 9 to 10 inches. By this operation the rows of the turnips are cleaned of all weeds, the superfluous plants of turnips cut up and pushed into the intervals where they die, and the plants to be preserved left standing at the distance required from one another. A transverse section of the drills will then appear thus :

Fig. 177.

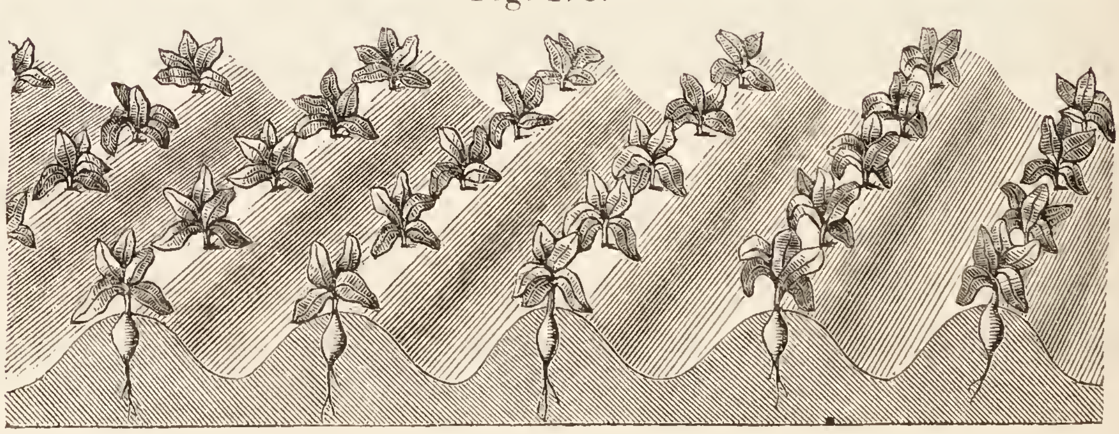


Soon after the operation in question, weeds will again spring up in the intervals of the rows and amongst the plants. In the course, therefore, of 12 days or more, the horse-hoe again passes along the intervals of the drills, cutting up all the weeds that may have sprung up; and afterwards the hand-hoers, with the same instrument as before, hoe round the plants, and carefully single any that may have been passed over in the first hoeing.

Sometimes the horse-hoe passes again along the intervals, but more frequently the hand-hoeing concludes the process, the weeds being now kept down by the rapid growth of the plants, and the overshadowing of the intervals by the leaves.

Very frequently, however, after an interval of 8 or 10 days from the last hand or horse hoeing, the earth is laid up to the stems of the plants by the double mould-board plough passing along the intervals of the rows, and ridging up the earth thus—

Fig. 178.



The design in this operation is, that any weeds remaining in the intervals after the former hoeings may be destroyed, and that the turnips may be kept more dry during wet weather in the months of winter.

This concludes the culture of the turnip, which now grows rapidly without further care; and by the beginning of September, the leaves of a good crop will have covered the entire surface of the field.

Towards the end of October or beginning of November, when the pastures are decayed, the turnips may be used for food.

The manner of consuming them is various, and dependent upon the kind of stock to be fed, and other circumstances:—

1. They may be pulled up and carried to a separate field, and spread upon the ground, or given to the animals from troughs.

2. Where sheep are to be fed, the animals may be penned upon the ground, and thus allowed to consume the turnips where they have grown.

3. The turnips may be pulled up and carried to the oxen or other animals in their feeding stalls or yards, in the manner to be afterwards explained.

4. The turnips may be taken up and stored in a convenient place for use. In this case they are to be pulled from the ground about the beginning of November or previous to the frosts of winter. In the act of pulling, a slight twisting motion is given to disengage the earth, and then the tap-root, and the tops or leaves, are cut off, each by a stroke of a hook or knife, care being taken not to wound or injure the root. The roots thus divested of their leaves and tap-roots, are to be carried to some convenient situation, placed on a dry base of 8 feet or more in breadth, and piled up as high as they will conveniently stand. The heap is then to be thatched with straw, and secured with straw-ropes, thus forming an oblong heap of the size required.

Turnips may be preserved by storing for some months, but they lose a portion of their nutritive juices, and become less palatable to cattle. They are, therefore, best consumed soon after they are taken from the ground. The reasons that may exist

for storing are: 1*st,* The necessity in countries where the winters are long and severe, and the snows deep, of having a surplus store in readiness; 2*d,* The expediency of clearing land for the purpose of sowing any particular crop, previous to the time at which it may be convenient to consume the turnips; and, 3*d,* The advantage of removing them from certain wet and clayey lands, before the season arrives when they could not be removed without injury to the surface.

Turnips suffer greatly from sudden alternations of frost and thaw in spring, particularly, when the heat is considerable, and when they have no covering of snow to defend them. There is no remedy for this evil but to consume the turnips, if possible, before putrefaction has begun. The storing process is a considerable preventive of the decay of turnips in spring. A practice, too, is sometimes resorted to, of covering the turnips in the rows where they grow before winter. This is done by the plough passing along the intervals, and raising the earth over the turnips, which is found to be a tolerably good defence against the effects of extreme frosts.

In frosts, the turnips are often so hard and frozen to the ground as not to be raised without great labour. In this case they must be taken up by hoes, it being impracticable to pull them by the hand. Often the turnips are cut into pieces before being given to the larger cattle and sheep. This is effected by the machine (Fig. 49 or 50) formerly described. But these and other details with respect to the consumption of the turnip, will be explained when treating of the rearing and feeding of live-stock.

Sometimes the turnip is cultivated for its seeds for sowing; and by careful selection, varieties of the plant may be multiplied and improved. A manner of procuring a good variety of turnip, is to pick out from the field in autumn or the following spring the largest and best formed turnips, with the smallest tops and tap-roots, and to plant them in some separate place in rows. The plants will flower in spring, and when their pods are formed, they are to be guarded from the depredations of birds, and the stems are to be cut down and well dried, and then either stored in stacks,

to be thrashed out when wanted, or thrashed at once, and the seeds preserved in the granary.

The diseases and accidents to which this valuable plant is subject are considerable.

The chief danger to it is in the early stage of its growth, when either the seed may not vegetate from a deficiency of moisture, or when the plant may be destroyed by the attacks of animals. Should the turnips fail from either of these causes, the sowing is to be repeated by simply driving the sowing-machine along the drills, or by again ridging up the compressed drills, and then sowing them.

The insect the most destructive to the turnip during the first stage of its growth, is familiarly known to farmers by the name of the turnip-fly. It is a species of beetle, the *Haltica nemorum* of entomologists. This creature attacks the plant as soon as the cotyledon leaves are upon it: when the plants have put on the second or rough leaves, they are regarded as safe from injury from the beetle, and hence a security against its ravages is a rapid and vigorous vegetation of the plant.

There are other creatures that attack the plant at this stage, and when it has escaped these early enemies, it is sometimes attacked by the larvæ of a species of saw-fly. These, however, are more partial enemies to the turnip plant than the beetle, though occasionally they are very destructive.

The turnip is liable to a kind of blight. Another of the diseases to which it is subject is a species of canker. The disease attacks the root, but its presence is first discovered by the leaves becoming flaccid and drooping. The roots, in place of enlarging into their usual form, shoot away into excrescences. They become acrid, and, even at an early stage of the disease, animals reject them. Towards autumn they become ulcerated, and at length decay. A species of maggot is found in them, but whether this be a consequence of the disease or a cause of it, has not been satisfactorily determined. This destructive disease has been long known in England, and frequently receives the name of "fingers and toes." It sometimes affects particular districts, and gene-

rally continues its ravages for many years in succession. The only sure remedy for the disease is to cease cultivating the turnip when it appears, and to substitute for a time some other species of crop. When turnips follow in a regular rotation, as at intervals of four or five years, by omitting them once, and substituting a crop of potatoes, the disease will afterwards be greatly mitigated, and sometimes removed.

The extended culture of the turnip has enabled us to carry the practice of breeding and feeding our domestic animals to a state of perfection, in which no other country has yet been able to rival Great Britain. The cultivation of the plant in rows, instead of the former method of broadcast, may well be regarded as an improvement of the highest importance. It has enabled the farmer to secure abundant returns, which the former methods of cultivation did not admit of, and so to increase the number of useful animals that may be maintained upon the farm, and to subject the lighter soils to a species of culture more beneficial than any other that had been before devised for them.*

2. Rape.

The plants usually cultivated under the name of Rape, are the fusiform varieties of the following species of Brassica :—

1. Brassica Napus—Cole or Rape.
2. Brassica campestris—Colza.
3. Brassica Rapa—Fusiform Common Turnip.
4. Brassica præcox—Early Cole.

Brassica Napus, Cole or Rape, is a native plant. All its leaves are smooth. When cultivated, it produces abundance of leaves and seeds. The leaves are used for food, and from the seeds oil is expressed.

Brassica campestris differs from the last in having its lower

* Paper by the Author on the Culture of the Turnip.—Quarterly Journal of Agriculture.

leaves slightly rough. It has been thought to yield a larger quantity of oil than the last.

The other kinds of rape, namely, the fusiform varieties of *Brassica Rapa* and *Brassica præcox*, are of more partial cultivation, and are not reckoned so productive of leaves and seeds as the other species.

The rape is a hardy plant, and has a wider range of soils than the turnip. It grows, like the turnip, on the lighter soils, but may be raised also on the stiffer, and even somewhat humid, clays. It requires less of culture and manure than the turnip, and, consequently, can be produced under circumstances in which the turnip cannot be properly cultivated.

The manner of cultivating the rape for its leaves is very similar to the manner of cultivating the turnip; but it admits of variations suited to the soil, the period of sowing, and other circumstances.

The land intended for rape should, as in the case of the turnip, be ploughed before winter. In the following season it should be cross-ploughed, harrowed, rolled, and cleaned of the roots of weeds. It then should be ploughed a second time, harrowed, rolled, and cleaned; and a third ploughing and series of harrowings being given, it will be fit for being sown.

The land may be formed into drills, manured and sown precisely as in the case of turnips, but with narrower intervals between the rows. A distance of 24 inches will suffice to admit of the operation of the horse-hoe.

The rape-seeds may also and conveniently be sown in rows upon a flat surface, and in like manner at intervals of 24 inches. Under this method, when the ground has been ploughed and harrowed, and the root-weeds have been removed, the dung may be spread upon the surface, as in the case of summer-fallow, and covered by the plough. After this the rape-seeds are to be sown in rows, and the land being rolled, the seeds will be covered.

Instead of dung, bruised bones may be employed. These should be well ground, and sown by a machine. Rape-dust may be also used, and this forms a good manure to the plant.

Whether the method of sowing on raised drills, or in rows on a flat surface, be adopted, the land is to be hoed after the plants have come above ground and fully assumed their second leaves. This may be done by the horse-hoes; immediately following which go the hand-hoers, who, with hoes 6 inches broad, single out the plants to the distance from one another of about 8 inches. Another horse and hand hoeing are given; and these complete the culture of the rape.

Very often, however, the rape-seeds are sown broadcast; and if the land is well prepared, good crops can be raised in this manner.

The rape admits of being sown later than the turnip, and therefore, when the land cannot be prepared in sufficient time for the turnip, it is yet ready for a crop of rape.

The great advantage which the culture of the rape presents, is the facility with which the plant may be produced, and on inferior soils, where the turnip could not be beneficially cultivated. The rape may often obviate the necessity of an entire summer-fallow upon such soils; for it may be eaten upon the ground with sheep in the month of September, and thus a crop of wheat be sown in the same year. Under this system, very inferior clays have been made to produce excellent crops of wheat.

The rape is frequently sown as a kind of intermediate crop. Thus, after a crop of corn has been repeated, rape may be sown upon the ploughed stubble, and will in the following spring yield a tolerable supply of green food.

After land has been prepared for summer-fallow, and when it is not intended to sow wheat in that season, but to take oats or barley in the following spring, then rape may be sown with advantage. In this case, the land being already well prepared, the rape will grow with vigour, and be ready in spring to be consumed before the spring crop is sown.

Rape, too, may be frequently sown after early pease and potatoes, and produce an exceedingly good crop.

It is for this kind of intermediate cropping that the rape is in a peculiar degree adapted. It may be sown, it has been said, much later than the turnip, and in cases where the turnip could not be produced.

Rape may be mown for forage, and will spring again. It is best, however, consumed on the ground by sheep penned upon it.

Rape bears well to be transplanted. It may thus be sown in seed-beds, and then transplanted to the place where it is to grow. By being prepared in a seed-bed, it can be got ready to be planted on stubble-land in autumn, as soon as the crop is removed. This practice, however, is chiefly applicable when the rape is cultivated for its seeds, and will be adverted to when considering the rape as a plant producing oil.

3. The Cabbage.

The Cabbage, commonly so called, is *Brassica oleracea.* This species assumes a vast variety of form and character. The wild cabbage, from which the greater number of the cultivated kinds are derived, is a little plant growing upon our sea-coasts. Yet to this plant we certainly owe the greater part of the numerous varieties cultivated in our gardens and fields. We cannot, indeed, be assured of the origin of all the cultivated kinds, for, besides the variations produced by climate and art, all the species of Brassica form hybrids with one another.

The different kinds in cultivation may be arranged in different classes, according to their general aspect and more popular characters :

1. Those which bear their leaves on stalks without their being formed into a head. Some of these have crisped leaves, and are a class of hardy pot-herbs everywhere familiar in the culture of the garden. Others have smoothish leaves with long branched stems. These comprehend the largest and most productive of all the cabbages,—the Jersey cole, the thousand-headed cabbage, and others.

2. Those whose leaves are formed into a large head. These comprehend the larger cabbages cultivated in the fields. The savoys of our gardens are allied to this class.

3. Those whose roots become napiform, as the Kohl-rabi.

4. Those in which the stem divides and forms a corymbose head, as the cauliflower and broccoli.

The cabbages of the first class, with crisped leaves, frequently termed Greens, are very hardy. They are cultivated pretty extensively in some parts of the North of Europe ; but in others they are chiefly regarded as pot-herbs, and confined to the garden.

The branched kinds with smoothish leaves are the most productive, but at the same time they require a good soil and favourable climate. Their leaves are stripped off as they are required for use ; and as these are constantly supplied by fresh leaves, the plants yield a succession of forage throughout a great part of the season, and they remain growing for several years.

There are different varieties of these larger cabbages, which are more or less valued in the places where they are cultivated. The thousand-headed cabbage, *Chou à mille têtes*, is remarked as possessing a greater number of shoots; the cow-cabbage, as growing more to one stem, and producing cream-coloured flowers ; the Jersey cole, as being similar in its growth, and producing yellow flowers.

In Jersey and Guernsey, where the cultivation of these plants is well understood, they are sown in beds in autumn, and planted out in succession from November till February. About the month of April, the farmers begin with the first sown to strip off their under leaves for use. They give them to their cows, hogs, and other stock. They cut them into small pieces, and mix them with bran and other farinaceous substances. During the summer they continue this process of stripping off the leaves, the plant in the mean time rising to the height of several feet.

This plant requires a good soil and plentiful manure, and is regarded as a great exhauster of the soil. It perhaps yields a larger proportion of nutriment within the same period than any other forage-plant. It may be presumed that it is not well fitted for general cultivation, and in this country will only succeed in favourable situations, as the south of England and Ireland, and the beautiful little islands where it is now cultivated.

The kinds of the cabbage which are best suited to general cultivation in the fields are the large-headed field-cabbages, as the Large Scottish or Yorkshire, the Drumhead, and the American. These and other names, however, are frequently applied where there is no real distinction. The varieties are all known by their large leaves, which, as the plant advances, collapse and form a dense head.

The next class consists of those in which the root becomes napiform. There are varieties of them, the principal of which is the Kohl-rabi. This plant is cultivated in Germany and the north of Europe. It is valued as a resource for cattle in winter. While it produces a root like a turnip, it at the same time sends forth stems bearing leaves like a cabbage. It is not only hardy, but keeps better in store than any plant of the cabbage kind. It may be cultivated in the same manner as the Swedish and yellow turnips ; but the experiments that have been made with it in this country lead to the inference, that it is not equal to those turnips for the purposes of feeding.

The cabbages of the last-mentioned class, as the Cauliflower and the Broccoli, are entirely limited to the garden.

Of the different kinds, therefore, it appears that the large field-cabbage, whatever name it may receive, is that which is best suited for common field-culture.

The cabbage may be cultivated like the turnip, being sown in drills, and tilled and sown in the same manner. The proper method, however, of cultivating the cabbage is to sow the seeds of it in the first place in beds, and then to plant it by the dibble or spade in the situations which it is to occupy.

The land is to be ploughed with a deep furrow in autumn, precisely as for the turnip : it is to be cross-ploughed in spring, harrowed and rolled if necessary, cleaned of root-weeds, and again ploughed; and the same operation of harrowing and collecting weeds is to be repeated. If the land is now in a fit state to be formed into drills, this is to be done ; if not, it is to be again ploughed, harrowed, and cleaned, and finally formed into drills 30 inches from centre to centre, the dung being spread as in the

case of the turnip-culture, at the rate of not less than 20 tons to the acre.

In the mean time the young plants are being prepared. For this purpose, the seeds must have been sown as early in spring as the weather allowed, on some land in good heart, well sheltered, and carefully digged. This should have been done in the month of March; and about the middle of May, or as soon afterwards as possible, the plants are to be set along the tops of the drills by the dibble, at the distance between each plant of $2\frac{1}{2}$ feet. It is well that the land be somewhat moist when this operation is performed.

The cabbage is usually intended for spring-food. If designed in any case for early feeding, the seeds should be sown in the previous autumn, and well protected from the frost. They will be ready to be planted out on the drills early in May, and they will be fit for use in October.

The intervals of the cabbage are tilled by the horse and hand hoe, as in the case of the turnip; and the distance of the plants affords the opportunity of doing this with effect. The last tillage should be that of earthing up the soil thoroughly to the stems of the plants.

Cabbages do not endure storing like turnips, and, therefore, they should be consumed nearly in proportion as they are pulled from the ground.

They should be carried to the yards and sheds, and given to the cattle in troughs or mangers, the stems being cut off by a hook or knife. When they are to be given to sheep, they should be carried to a dry field, and laid upon the ground. They may be boiled or steamed, but they are usually given in a raw state. They are relished by all herbivorous animals, and furnish a wholesome nutritive food. They are chiefly valued, however, for the feeding of milch-cows, to which purpose they are largely applied in some of the dairy districts in England.

The cabbage is a more nutritive plant than the turnip, that is, will feed a greater number of animals from the same extent of

ground. It is suited to a different class of soils from those to which the turnip is suited, the soils best adapted to the cabbage being the clayey.

The cabbage is generally regarded as an exhausting crop. In this respect it probably follows the law of all plants that yield a great degree of nourishment, abstracting a corresponding quantity of matters from the soil. But then if it returns back a corresponding quantity of manure by its consumption, it cannot be said to be an exhauster of the farm. On the Continent, and in the districts of England, where it is cultivated, it is known to be a plant that requires a good supply of manure. But then it is known to be a rich forage-plant, and calculated to replace that manure by its consumption on the farm.

The expediency, however, of extending the culture of the cabbage in any part of the country, depends mainly upon the nature of the soil and climate.

The turnip and the potato, for the feeding of live-stock, are more readily and safely raised over a great part of the soils of this country; and hence the culture of the cabbage is more confined to particular situations, and these where the climate and other circumstances are favourable. Thus, north of the Tweed, the cabbage, though often tried, has never been greatly cultivated, and it is not until we reach the more southern parts of the kingdom, that the culture of the cabbage can be said to be fairly established as an object of field-culture. There the crops of it are heavy in proportion to the crops of turnips; while in the more northern parts of the country, the crops of turnips are heavy in proportion to the crops of cabbage.

Nevertheless, even in the parts of this country less favourably situated, there are many cases, in clay-land districts, in which the cabbage may be substituted for the bean in the rotation. But whether or not it be expedient to introduce the culture of the cabbage as a regular part of the rotation, it can always be cultivated successfully on the small scale. It is on the smaller possessions, accordingly, that we see the most frequent patches of the cab-

bage; and this is as it should be, because the state of possession admits of more attention being paid to the tillage and manuring of the plant, than might be consistent with the regular labours of a more extended farm.

4. The Potato.

This plant, of the genus *Solanum*, is of the natural order *Solaneæ*, or the Nightshade tribe. The juices of the plants of this family possess certain narcotic and stimulating properties which in excess are poisonous. But these properties exist in different species in different degrees; so that, while some of them, as the deadly nightshade, are highly poisonous, others are merely narcotic, and others yield common articles of food. Even the tubers of the common potato, which are regarded as so nutritive, possess certain poisonous properties, which are expelled by heat, in the process of preparing them for human food. Of the species of Solanum, several are cultivated in different countries for their uses in domestic economy and the arts; but of all the species, the most important to the human race is—

Solanum tuberosum—the Tuberous-rooted Nightshade, or Potato.

This species is a native of America, and it has been observed that it is the most precious gift of the New World to the Old. It appears to have reached Europe from the Spanish Settlements; but it came to England from Virginia, being brought to it, as is supposed, by the brave and unfortunate Sir Walter Raleigh. The history of its introduction into the various countries of Europe and Asia is remarkable. It was for the most part received with tardiness, distrust, or contempt; while another plant of the same natural family, the Tobacco, possessing merely the properties of a narcotic, was no sooner made known, than it was received with eagerness in every part of the habitable world.

The use, however, of the potato has constantly extended; it forms now a great part of the food of the inhabitants of Europe, and its more general consumption has, beyond all question,

lessened the hazards of famine, and added to the comforts of the labouring people. It grows exempt from the hazards to which many of the other crops are subject. Its tubers ripen in the earth, and so are defended from the effects of winds and storms. It yields a large quantity of fecula, which can be obtained separately from the tuber. It may be used in its natural state, either directly as the food of man, or for the feeding of domestic animals. It has a wider range of soils and temperature than most other cultivated plants, grows on soils the lowest in the scale of fertility, and is capable of supporting a greater number of human beings upon the same extent of ground than almost any other plant cultivated in the temperate regions. Under every system of agriculture, it is a beneficial object of culture; and to the settlers of new countries, it is, of all the cultivated plants, the securest, the most easily produced, and the least liable to the contingencies of the seasons.

The potato rises with a branched and succulent stem bearing white or purplish flowers. The fruit is a round berry, of the size of a little plum, green at the first, but growing black when ripe, and containing numerous small seeds. The root has many tubers attached to it of a round oblong form.

The potato may be propagated from its seeds, and it is in this way that new sorts are obtained; or it may be propagated by planting the tubers, in which case plants similar to the old are produced.

When the plants are propagated from the seeds, they require to be planted for several successive years before the tubers attain their full size. When they are raised at once from the tubers, they yield their full produce in one season; hence, when the purpose is to obtain tubers for food, they are always produced by planting the tubers.

But one tuber generally contains many buds or germens, from each of which a stem will arise: hence it is not necessary to plant the whole tuber, but only such part of it as may contain one of these buds or germens.

The tuber, therefore, though it may be planted entire, is for

the most part cut into several pieces, care being taken that each piece shall contain at least one bud, or eye as it is termed. These buds are sufficiently visible on the surface of the tuber, and hence the operator has no difficulty, by cutting the tuber through longitudinally or transversely, as may be required, in preserving one bud at least upon each piece. Small tubers are generally cut into two, the larger into three, four, or sometimes five pieces, if the potato be very large. When they are cut a considerable time before being planted, they should be spread on the ground, and turned from time to time, that they may not ferment. When proper care is bestowed, large and well-shaped tubers are selected for planting.

Many approve of planting the entire tuber, a practice to which no objection exists, further than that experience shews, that nearly an equal effect may in most cases be produced by dividing the tuber, while there is a certain economy in the practice. Nevertheless it is certainly better to plant the whole tubers. Others have recommended the merely scooping out of a small part of the tuber containing the bud, and planting the pieces, and doubtless good crops have been raised in this way. The approved practice, however, and beyond a doubt the proper one, is either to plant the tuber entire, or to cut it into pieces, so that one eye at least shall be upon each.

It has been observed that eyes taken from tubers that have not been fully ripened, are more vigorous than those that have been taken from such as have been very fully ripened. This leads to a rule in practice, that the tubers to be planted shall be those which were taken up before the stems had begun to decay in autumn.

It has been observed, too, that eyes taken from the upper part of the tuber, which is always less matured than the lower part,—and which hence is called the watery end in contradistinction to the other, which is called the mealy end,—ripen earlier than those taken from the lower or mealy end. This has given rise to a practice adopted in some places, where very minute care is bestowed on the culture of the potato, of dividing the tuber transversely

into three parts, and planting the sets separately: those taken from the upper or watery end for the early crop, the centre ones for the intermediate crop, and the lower ones for the later crop. But such niceties, it is to be observed, are in no way essential in the common practice of the farm.

The varieties of the potato, as produced first from seeds and afterwards continued by sets, are exceedingly numerous, and constantly varying as the old ones degenerate, or as better ones are brought into notice.

The most obvious distinction of the varieties of the potato is into the early and the late. The power of early-ripening exists in a greater degree in certain individuals than in others: the early-ripening kinds are thus obtained in part by selection, and the property becomes permanent in the progeny. The early potatoes are more raised in the garden, the late ones in the fields. But very often the early potatoes are also raised in the fields, and where a demand exists for their produce, as near large towns, they can be cultivated in the field as well as in the garden. Potatoes, with relation to their periods of ripening, may be classed as follows:—

1. The earliest kind used by gardeners, which are generally termed forcing potatoes. These are not at all intended for field-culture.

2. Early kinds, which may be subdivided according to their order of ripening: First, the earliest sorts in common cultivation, as the Early-shaw, the American-Early, the Early-champion, and others; second, an intermediate class, which would be considered as late in the gardens but early in the fields; such are those termed the Early-red, the Cape of Good Hope kidney, and the Bread-fruit.

3. The later kinds, forming the common subjects of cultivation in the fields, which may, in like manner, be subdivided according to their order in ripening; such are those termed the Red-apple, the Bedfordshire kidney, the Lancashire pink, and numerous others.

4. Those of a large kind, but of so coarse a nature as to be

cultivated only for feeding domestic animals; the best known of which are the Late-champion, the Ox-noble, and the Surinam.

New varieties of the potato are obtained, it has been said, by cultivating from the seed. Many of the early potatoes, however, do not blossom at all. To obviate the effects of this, Mr Knight adopted an expedient which deserves to be noticed, both as being calculated to effect the purpose intended, and as illustrating the habits of the plant. He removed the tubers as they were being formed, by which means he directed the vegetable juices to the stem and parts of fructification, and so was enabled to produce blossoms and seeds.

The mode of procuring new varieties from seeds is simple, but tedious. Some of the largest and best-formed berries, when fully ripe, which is denoted by the change of their colour, and by the stalk having become withered, are plucked, and the pulp is separated from the seeds, which are then dried in the sun. These seeds are to be sown in the following spring, and the produce is to be taken up early in October. The tubers will then have nearly attained the size of small plums. The best of these are to be selected and carefully preserved. In the month of April following they are to be planted at a distance from one another of from 15 to 18 inches; and when they rise about 2 inches above ground, they are to be covered with earth by the hoe, which operation may be repeated during the season, and they are to be kept free from weeds. When they have arrived at maturity, which will be denoted by the decay of the several stems, they are to be taken up in succession as they ripen, keeping the early separate from the late: and the produce of each stalk is again to be planted in the following spring. A judgment of the properties of the potatoes will then have been formed, and those are to be reserved for cultivation which are approved of. It will be found that, whatever had been the parent stock, the seeds will produce numerous varieties, some white, some dark in the colour, with tubers of different forms, round, oblong, and kidney-shaped. This is a tedious process, but necessary when it is desired to cultivate new varieties from seeds.

The soils best adapted to the potato are of the drier and lighter class. In stiff clays the return is often inferior in quality and productiveness. Deep dark peat frequently produces large crops; and it is one source of great value in this plant, that it can be cultivated successfully on the soils termed peaty.

Potatoes, in the common course of farm-culture, are cultivated by the plough; but they are frequently also, and this in many cases with great convenience, cultivated by the spade; thus, in woods in new countries, in plantations and steep banks inaccessible to the plough, or, in certain cases, in peat too soft to bear the treading of cattle, the spade may be beneficially substituted for the plough.

An example of this method of culture is what is termed the lazy-bed system. This consists simply in forming beds of a few feet in width, with intervening spaces or trenches: these beds being digged, the dung is spread upon them, and the potatoes are planted in rows upon the manure at distances from one another of ten inches or more. They are then covered with earth thrown upon them from the trenches, and generally, after they have appeared above ground, they receive a second covering of earth, so as to be covered in all to the depth of from 4 to 5 inches.

Inartificial and rude as this method may seem, there are cases in which it can be practised with advantage; such as in deep bogs, where the plough cannot act, and peaty soils which are brought under culture for the first time. And it is surprising how large the crops are which are sometimes raised in this manner, and in how good a state the land is left, from the deep tillage which it has received.

The cultivation of the potato, however, upon the larger scale of farm-culture, must necessarily be performed by the plough and the working-cattle upon the farm.

The potato forms a good preparative crop for any of the cereal grasses; and it may follow any crop of corn. Sometimes potatoes are planted upon land newly broken up from grass. In this way they may be cultivated beneficially in regard to produce; but this is a deviation from the general rule, that the potato shall follow a crop of corn, and be succeeded by one.

As in the case of preparing land for the summer-fallow, the land intended for potatoes is to be ploughed before winter, receiving a furrow of 8 or 9 inches in depth. The ploughing should be lengthwise, so as to keep the ridges dry, and prepare the ground for early tillage in the following spring.

In spring, as soon as the other labours of the farm allow, the land, when sufficiently dry, is to be cross-ploughed, and harrowed by repeated double turns of the harrow in every direction. The roller also, if necessary, is to be employed to reduce the soil, and all the root-weeds are to be carefully collected by the hand, and carried away to be formed into a compost, as was described in the case of the management of summer-fallow.

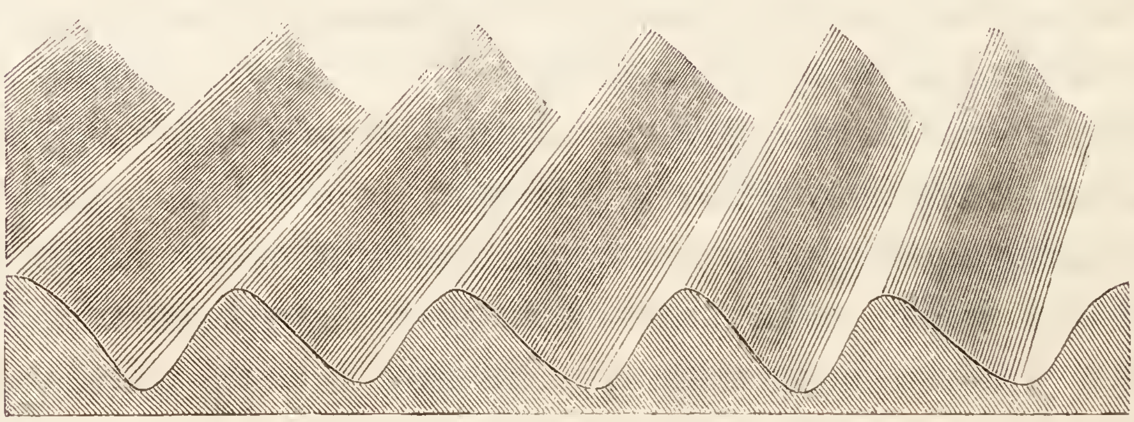
The land is next to be ploughed in a direction crossing the last ploughing, or rather the ploughs may cross the fields diagonally, because, as it is always desirable to make each alternate ploughing cross the previous one, and as the next ploughing, which forms the drills, will be in the direction of the former ridges, all the ploughings will thus be made to traverse one another.

When this second ploughing is given, the land is to be again harrowed and rolled, if necessary, and all the root-weeds are to be industriously collected and removed as before.

These operations will generally fit the land for being formed into drills. This may be done by single-bout drills, as in the case of the bean; but it is better performed by double-bout drills, as shewn in Fig. 173. The distance from centre to centre, or, in other words, the breadth of the drills at the base, may be 30 inches.

A transverse section of the drills will appear thus :—

Fig. 179.



When the drills are formed in this manner, the dung is to be

carried forward to them, and spread in the hollows, precisely in the manner described in the case of the turnip.

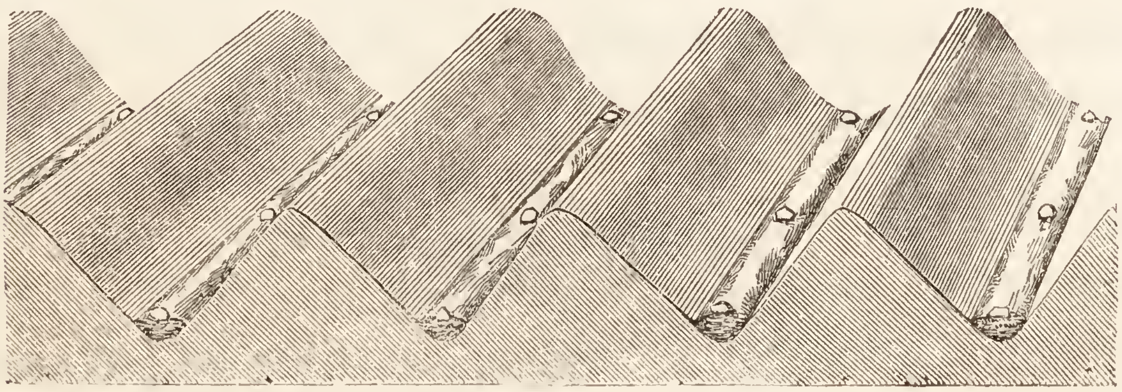
Dung will, in all cases, act the most quickly upon young plants when it is well prepared, but extreme preparation of the dung is not required in the case of the potato. It is enough that it be in such a state of decomposition as that it may be readily covered by the plough.

The potato requires a large supply of manure. The quantity should be from 16 to 20 tons to the acre, and when a larger quantity can be supplied it is well, the goodness of the potato-crop being greatly dependent upon the quantity of manure applied.

The proper manure for the potato under ordinary circumstances is common farm-yard dung. But any other putrescent manure that can be obtained may be applied. Bone-dust has been employed, and with good effects. Lime does not appear to act in a beneficial manner, and is rarely applied directly to this crop. But any of the alkaline salts, or even common salt, may be applied with advantage to this crop, along with putrescent manures.

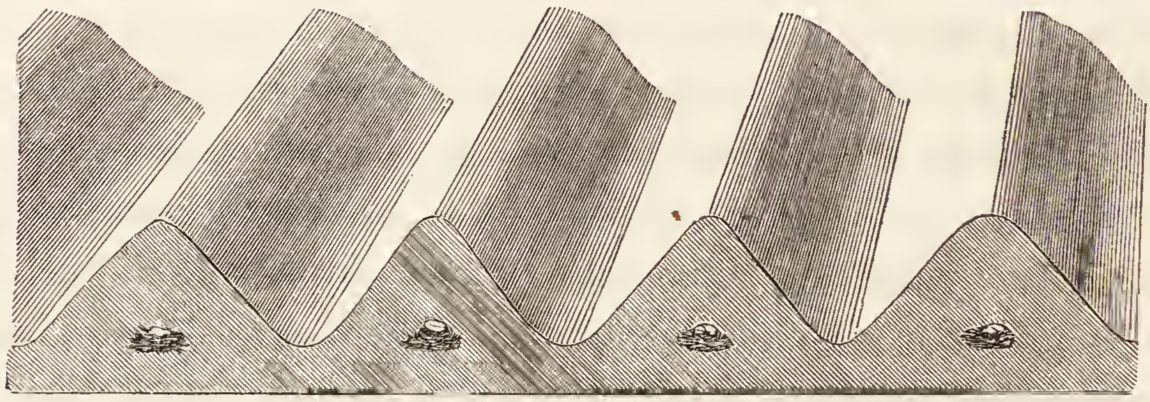
As soon as the dung is spread along the hollows of the drills, the potatoes are to be planted. When sets are used in place of the entire tubers, they should be cut 10 or 12 days before planting them, by which the cut part acquires a skin or indurated surface, which is supposed to protect the sets from injury when first planted. The sets are placed directly upon the dung in rows, about 10 inches from one another; the entire tubers at a foot or more. The planters carrying them in baskets, gently plant them upon the dung, directed by the eye, as nearly as possible at the distance required. A transverse section of the drills, with the dung and potato sets placed upon it, will appear thus:

Fig. 180.



The sets are now to be covered by splitting each drill so that the top of the new drill formed is immediately above the hollow of the old one. The manner of performing the operation is the same as that described in the culture of the turnip. A transverse section of the drills, when split, will appear thus:

Fig. 181.



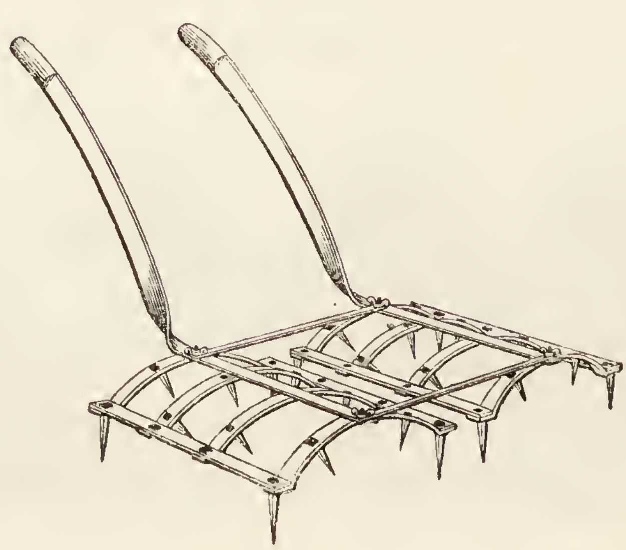
This simple series of operations completes the planting of the potato.

The usual period of planting is during the month of April, but it may be continued till the middle of May. The early potatoes should be planted by the latter part of March. The quantity planted may be from 8 to 10 cwt. to the acre, according to the size and distance of the sets.

In a fortnight or more after planting, the whole field is to be harrowed.

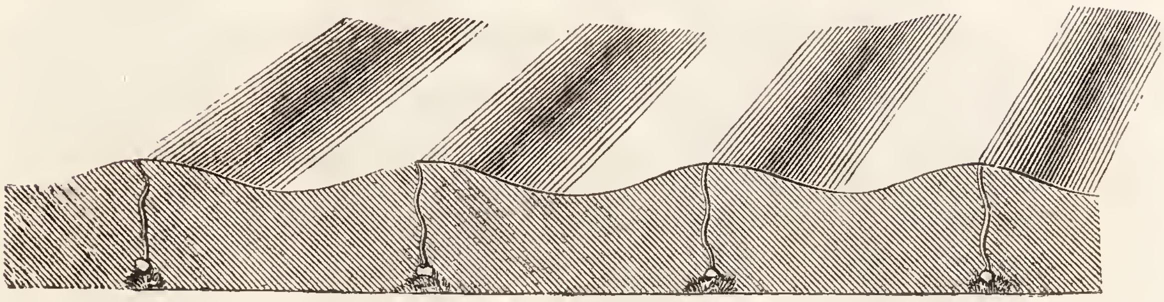
This may be done by the common harrows; or there may be used two very small light curved harrows with handles, each embracing a drill, attached to one another by hinges, and drawn by a single horse, which moves along the hollow of a drill, the workman walking behind and pressing gently upon the handles.

Fig. 182.



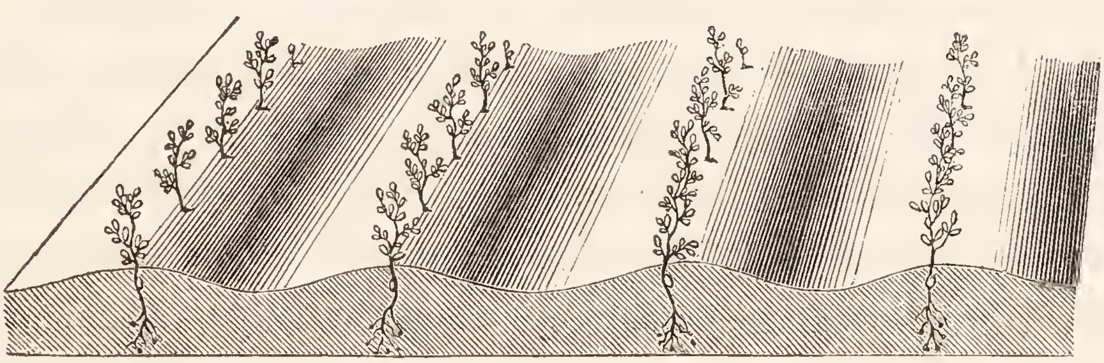
The effect of this tillage will be partially to level the ground, making a transverse section of the drills appear thus:

Fig. 183.



When the plants have got above ground, and appear distinctly in rows, the horse-hoe is to pass along each interval, care being taken not to go too near the plants. Following the horse-hoe, the hand-hoers, each with the common hoe, are to hoe the rows of plants, carefully cutting up all weeds that may have escaped the action of the horse-hoe. A transverse section of the drills after this operation, will appear thus:

Fig. 184.



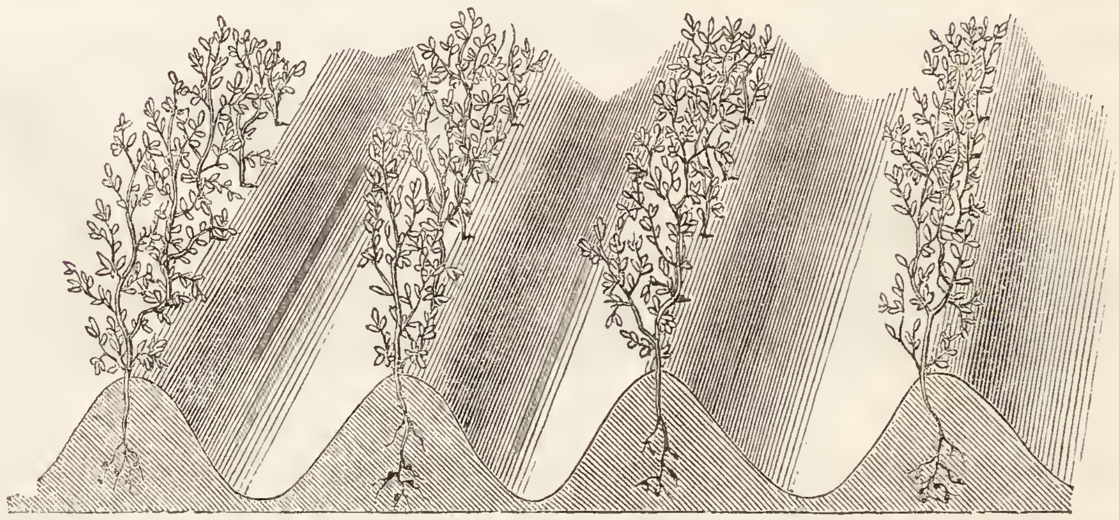
After an interval, as a fortnight or more, the horse-hoe is again to pass along the intervals. Immediately succeeding the horse-hoe, the hand-hoers are to follow as before, hoeing round the plants, and cutting up all weeds.

This is generally sufficient to clean the land in an effectual manner, though sometimes, when it is exceedingly full of weeds, a third hoeing may take place.

The last operation is raising the earth to the stems of the plants. This is done by a double mould-board plough passing once along the intervals, and throwing up the earth towards each

row. A transverse section of the ground will then appear thus :

Fig. 185.



This in all cases completes the culture of the potato. The plants will now grow with quickness, their stems spreading over the intervals, and covering the entire ground.

The method of culture described is suited to clean the ground of weeds in a manner simple, cheap, and efficient; but it is certain that the action of the horse-hoe with its coulters tends to displace and injure the tubers in the course of being formed, and that larger crops are produced, by planting the tubers in the manner of gardeners, with a flat surface, and employing only the hand-hoe. But in place of the horse-hoe, there may be employed simply a double mould-board plough, to stir the earth, and throw it towards the stems of the growing plants. This operation repeated thrice, or at the most four times, during the season, will supersede the necessity of employing the horse-hoe. In the first earthing up, the ploughing should be very shallow, in the second a little deeper, and in the third it should be to the ordinary depth.

The crop after the last hoeing, requires no further attention until the tubers are ready to be taken up when ripe, which is generally in the month of October.

The operation of taking up the tubers may, upon the small scale, be performed by digging them up with a three-pronged fork ; but, on the large scale, it is to be performed by the plough.

The plough, from which the coulter has been previously taken, is to pass with a deep furrow along the centre of the drill, and thus reverse one-half of it. It is to be followed by a sufficient number of persons to collect the potatoes into baskets. It is then to return by the same drill, reversing the other half of it, so that the whole tubers of the drill are turned up. Time is saved in this operation by the plough, after laying open the half of one drill, passing to another drill, where there is a like number of persons to follow it, and so on to another and another. It then returns to the first drill, and reverses the other half of it, and so on in succession with the other drills. Often, however, the plough reverses an entire drill at one turn. After the plough has reversed the different drills, the harrows should follow, so as to bring to the surface any tubers that may have escaped. In this manner the gathering of the potato-crop, which in many cases is regarded as a work of time and labour, is performed with economy and despatch.

It is important that the potatoes be taken up in dry weather and before frost. They may be preserved in various ways, the purpose being to secure them effectually from frost, and prevent them from putrefying.

Sometimes they are conveyed at once to a house, and stored in it, to be ready for use or sale. But the more frequent practice is to form them into oblong heaps, and to cover them carefully with a thick layer of straw, and this again with a coating of earth. There is no better non-conductor for this purpose than straw. When any heap is to be opened for use, bunches of loose straw should be employed to defend it from the air. Even when the potatoes are kept in houses, they should be carefully covered with dry straw, to prevent the action of frost upon the tubers.

After the potato, the usual crop sown is wheat, for which the ground is well prepared by the operations of the potato-culture.

The later and common varieties, it has been said, should be planted, if possible, in the month of April. The early varieties should be planted before the end of March. Under good cultiva-

tion and favourable circumstances, the latter will be ready to allow a crop of turnips or rape to be sown in the same year.

Potatoes, it has been seen, are planted in spring, after the land has been prepared for them; but potatoes may likewise be planted before winter, provided they are sufficiently covered with earth to be defended from the winter frosts. In some parts of the south of England, potatoes are planted before winter, and are thus ready very early in the following season. They are planted in October or November, 9 or 10 inches under the surface, and well covered with litter or dung. They appear above ground in March, and are ready by the middle of May. In some cases even, by planting in October, a crop can be raised before the winter frosts set in, which is used during winter.

It has been often recommended to pinch off the blossoms of the late potatoes, so as to prevent the formation of seeds. This has been deprecated by some, but recommended in an especial degree by Mr Knight, who asserts that more than a ton of additional tubers per acre will be procured by this means. Certainly an increased produce will be obtained if the operation is performed sufficiently early. A female or a boy will pluck off the blossoms of from 1 to 2 acres in a day.

The produce of the potato varies so greatly, that it is difficult to say what may be regarded as a medium return. Generally speaking, the crops produced in England and Ireland are greater than those produced in Scotland. In Lancashire, the produce is reckoned to be from 8 to 12 tons per acre. In most parts of Scotland, a fair produce is held to be 8 tons per Scotch acre, which is equal to $6\frac{2}{5}$ tons per English acre.

The starch or fecula of the potato may be obtained separately by simple means, and applied to various purposes of domestic economy. The quantity is generally from about a fourth to a fifth part of the whole weight.

This substance is perfectly nutritive, but, wanting gluten, it does not undergo the panary or bread fermentation. It is not, therefore, so well suited to the making of bread as the flour of wheat. It may, however, be mixed with the latter in a given

quantity, so as to produce good bread; and it is suited to those other purposes of domestic economy in which the panary fermentation is not required. The use of the starch of the potato has been gradually extending in various forms, by which the utility of the potato, as a branch of husbandry, is likely to be greatly extended.

The potato yields a large quantity of ardent spirits by distillation, for which purpose it is now extensively employed in the distilleries of Germany and the Netherlands.

The potato may be given in its raw state to nearly all our domestic animals. It requires merely to be washed, which is done by various simple means. One of these is by a cylinder or barrel, with a wooden axle, to which are attached sparred arms. These being turned round by a handle fixed to the axle, the potatoes in it are put in motion, and, the cylinder being partially filled with water, they are washed by a few turnings of the handle. The water is let off at the bottom by a stop-cock; and when the cylinder is large, a hinge-board is made to open and shut at the side or bottom, by which the potatoes are removed. Other contrivances for washing are resorted to, which need not be described. The principle of construction of them all is to give a sufficient motion to the roots when immersed in water.

But although potatoes may be given to live-stock in their raw state, and it is frequently convenient to give them in that state, yet various benefits may arise from giving them steamed or boiled. In this state they are relished by every class of our domestic animals, and afford food in a high degree nourishing and salubrious. Even the dog, which will not touch raw potatoes, will fatten upon them when boiled.

Boiled potatoes, mixed with cut straw or hay, may be given to horses of every kind, even when on the hardest work, and this forms a species of food both wholesome and economical.

They may be given in this state to dairy-cows, or to any kind of cattle, for the purpose of fattening. But it is observed, that boiled food is not generally attended with the same benefit to ru-

minating as to other animals. To hogs it is given with the best effect. When fowls are reared in quantity, their food may be considerably economised by mixing the boiled potato with meal. An apparatus for preparing the potato for these various uses by steam has been already described (Fig. 53).

Of the accidents and diseases to which this plant is subject, one, the longest known, is termed *curl*. It is indicated by the curling of the leaf, and hence the name. It has been supposed to arise from a certain decay of vigour in the plant, which unfits it for the production of tubers. In cultivating the potato as we do, solely from tubers, we deviate from the natural habit of the plant, which tends to produce its species by seeds as well as tubers. When we cultivate solely from tubers, therefore, we do a certain violence to nature; and it may reasonably be concluded, that the vigour of the plant is impaired. To prevent this, we have the means of obtaining new plants from the seed, and thus a method of restoring their natural habits, and renewing their vigour.

But a disease far more destructive than the curl has recently attacked the potato crops of this and other countries. It has prevailed extensively in certain parts of North America, and has appeared in Europe, extending over large tracts of country, sometimes disappearing as suddenly as it came, and sometimes visiting the same place for more than one year in succession. In this respect, it has been supposed to resemble those endemics which sometimes affect the animal kingdom, and which are more or less destructive and long-continued. But however this be, no satisfactory explanation has yet been given of the predisposing causes of the malady, nor have any means of remedy been as yet discovered. The taint appears in the descending tap-root, and may be seen extending by the connecting rootlets to the tubers, into the substance of which it enters, producing putrefaction. It appears, at the same time, to extend upwards through the stem and leaves, which become covered with fungi, and assume the same blackened appearance which they do when injured by early frosts. Sometimes the stem and foliage continue vigorous, while putrefaction

has begun in the tubers; and sometimes the stem and foliage are covered with their characteristic fungi, while the tubers are scarcely affected. Some particular varieties of potatoes have been less affected than others, but none can be said to escape; nor does any particular condition of the soil as to previous culture, or the kinds of manure employed, appear materially to modify the disease. The occurrence of a disease so new and destructive over large tracts of country, under every condition of soil and temperature, gives cause for apprehension that we cannot depend, in the same degree as hitherto, on the produce of the potato plant as a main part of the food of the people.

The potato, notwithstanding the casualties to which it may be subject, is of high importance in this and other countries. It can be cultivated on the large as well as on the small scale,—by the manual labour of the peasant as well as by the plough,—and with more or less success, in every soil where cultivation is practicable. And it has done more than any of the cultivated plants to bring nearer to a level the value of different soils of the country; because crops of potatoes can be produced on inferior light soils, and on deep peat, often equal to those on the superior loams.

5. The Carrot.

The Carrot, *Daucus Carota*, is of the natural order *Umbelliferæ*, an extensive family, which, like the *Solaneæ*, contains species that are highly nutritive, and others that are poisonous. Of the latter class are the hemlock; of the former are various well-known esculent herbs, as the carrot and the parsnep. The tribe of *Umbelliferæ* generally is suspicious and dangerous, except that the seeds are innocent; and many of them are cultivated for the aromatic qualities of their seeds, as the coriander and others.

The wild carrot, *Daucus Carota*, is a native species, familiar as a weed, under the name of bird's nest, from the resemblance of its

umbellated top to a bird's nest. By what accident this plant, with its slender fusiform root, has been changed into the plant of our gardens, is unknown. It is probable that the latter has been derived from warmer countries, and not from the wild plant of northern Europe, which no cultivation has been able to change.

Of the cultivated carrot there are many sorts, distinguished by their colour, size, and form. The most esteemed for field-culture in England are the Orange, the Long-red, and the Altringham.

The carrot, from its long fusiform root, requires a deep soil. It prefers the sandy, and rejects the stiff clays. Large crops of it are sometimes produced on a deep rich peat; but the proper soil for it is a sandy loam.

The land intended for carrots should be ploughed with a very deep furrow previous to winter, and at this period the dung should be applied at the rate, if possible, of from 15 to 20 tons to the acre. So essential is it to plough deep for this crop, that it is common to make the first ploughing a trench-ploughing, one plough following in the track of the other. In some parts of the Continent the spade is made to follow the plough, in order to deepen the furrow.

In spring the land is cross-ploughed and well-harrowed, and all root-weeds are removed. It is again ploughed, and the same operations are repeated; and, if it be necessary, the ploughings and harrowings are to be given again and again, until the soil is reduced to a proper tilth, and all the vivacious roots of plants collected and removed.

The plant may now be cultivated in three ways;—

1*st*, The land may be formed into drills, and the seeds sown on the tops of them in the same manner as those of turnips.

2*d*, The seeds may be sown in rows, but without being on raised drills.

3*d*, The seeds may be sown broadcast.

When the plant is cultivated in the first of these modes, the operations of hoeing and cleaning are nearly the same as those of the turnip, the horse and hand hoe being employed in succes-

sion to till the intervals and the plants in the rows. But the seeds having many hooked hairs on their surface, they adhere to one another, on which account the machine for sowing them must be peculiarly constructed, so that they may be separated in sowing.

The next method of cultivating the carrot is in rows, but not on raised drills. In this case, where the land is fully prepared, the double mould-board plough is to form it into shallow drills, at the distance, from centre to centre, of 12 or 15 inches; and in the ruts or hollows of these drills the seeds are to be sown. This may be done by a sowing-machine suited to the nature of the seeds; or it may be done by the hand, in the same manner as gardeners do, mixing the seeds with a little dry sand, and rubbing them in the hand to make them separate. The seeds are then covered by a slight harrowing. This is a sufficiently good method of cultivating the carrot.

The other method of cultivating the carrot is broadcast. This is practised in the Sandlings in Suffolk, where the culture of the carrot is successfully carried on, and where large returns are obtained. The same method is practised in the Netherlands, where the carrot is highly valued as a crop, and carefully cultivated.

Of these three methods, the best under ordinary circumstances is that of rows, either on a raised or flat surface, but in the latter case, making the rows at such a distance that the horse-hoe can act, as in the case of the turnip and other fallow-crops.

The seeds of the carrot should be of the previous season's growth, otherwise they may not vegetate; and care should be taken in all cases to try them before they are sown, the most frequent cause of the failure of the carrot being the badness of the seeds.

The quantity of seeds may be 3 or 4 lb. to the acre, when sown in rows, and 6 or 8 lb. when sown broadcast. The most approved period of sowing is the beginning of April.

When the plants are fairly above ground, they are hoed to the distance of 3 or 4 inches. This operation is to be performed with great care, as it is difficult at this period to distinguish the carrot from the weeds in the rows. In three weeks or less the

carrots are again hoed, and set out at the distance from one another of about 10 inches. In a few weeks or more, or whenever weeds appear, the operation of the hand-hoe must be carefully repeated. These three hoeings will be sufficient to complete the summer culture of the carrot.

The carrots may be taken up and stored about the end of October, or, which is better, they may be left in the ground and pulled up as required. When carrots are to be stored, they are taken up in dry weather, and their leaves cut off close to the root. They may then be put in narrow oblong heaps, the tails and heads being packed together, and the whole covered with a coat of straw. If taken up when dry, carrots will keep well in these heaps, without any other precaution than defending them from frost.

The produce of the carrot, in circumstances that are favourable to it, will be from 300 to 400 bushels to the acre, though much beyond this quantity is sometimes produced.

Carrots may be given to every kind of stock, and they form in all cases a palatable and nutritious food. They are given in their raw state, though they can be steamed or boiled in the same manner as other roots.

The live-stock to which they are most frequently given is horses and dairy-cows. They are found in an eminent degree to give colour and flavour to butter, and when this is the end to be aimed at, no species of green-feeding is better suited to the dairy. To horses they may be given mixed with cut straw and hay, and thus given, they form a food which will sustain horses on hard work. They afford excellent food for hogs, and quickly fatten them. When boiled they will be eaten by poultry, and, mixed with any farinaceous substance, form an excellent food for them. They may be used for distillation, affording a good spirit.

Although the return of this crop is, on soils and situations suited to it, very valuable, it is only in certain situations that it can be beneficially cultivated, and for this reason it does not form an object of general interest in the agriculture of this country. When circumstances admit of its being introduced into the rota-

tion, the essential points to be attended to are, that the soil on which it is grown shall be deep and of the lighter class, that the tillage shall be deeply given, and that the seeds shall be fresh and of the proper kind.

6. The Parsnep.

The Parsnep, *Pastinaca sativa*, in its uses, and the manner of cultivating it, resembles the carrot. It is a native of many parts of Europe and of Asia. The wild plant has a slender root, with downy leaves: in the cultivated variety the leaves are smooth, and the root large and mucilaginous.

The most extensive cultivation of the parsnep in this kingdom is in the islands of Jersey and Guernsey. The large Jersey parsnep is the kind most approved of for cultivation, whether in the garden or the field. It grows freely on the deep disintegrated gneiss of these islands, sometimes extending three or four feet into the soil. There are two kinds of it, one of which is fusiform, and strikes deeply into the earth, the other becomes thick and tends to the napiform.

The seeds of the parsnep may be sown either in autumn or in spring. The latter period is generally adopted, but the autumnal sowing is well suited to the habits of the plant.

When it is to be cultivated in spring, the land intended for it is to be ploughed in autumn with a deep furrow. It is to be cross-ploughed in spring, and tilled and cleaned, in so far as the earliness of the season will allow; for the parsnep must be sown at an early season, the common period usually being the month of March.

The parsnep may be sown on a flat surface, in rows, like the carrot, the plants being kept at a somewhat greater distance from one another. But sometimes the seeds are sown in beds in autumn, and transplanted when the soil is prepared.

The parsnep might also be cultivated in drills precisely like the turnip and potato. Nay, this seems to be the best mode of raising it; because an increased deepness, eminently favourable

to the habits of the plant, will be given to the soil. If cultivated in this manner, the drills may be no wider than is necessary to admit the horse-hoe, as 24 inches; and the plants may either be planted in the drills from previously sown beds, or the seeds sown in the manner of the turnip, and hoed out to a distance of 8 or 10 inches from one another. The method of transplanting would probably be the better, as in this case the plant would not need to be planted in the drills till the month of April, when the land could be better prepared.

All the after-processes of tillage may be the same as for the carrot.

The seeds must be new, because when they are more than one year old they frequently do not vegetate. The seeds are very light, but they do not adhere in the same manner as the seeds of the carrot, and hence are more easily sown.

The parsnep has a wider range of soils than the carrot, and, unlike the carrot, seems to prefer those which are more or less clayey.

The plant is ready for use when the leaves begin to decay. It may be taken up and stored like the carrot, or left in the ground to be pulled when required for use. It is not apt to be injured by frost; but it should not be left in the ground after the beginning of February, because, as soon as the flower-stalks begin to form, the roots become hard. The produce is generally greater than that of the carrot.

Its uses for domestic purposes are well known. It is a useful esculent for the garden of the cottager. When persons abstain from animal food, as in Catholic countries, the parsnep is regarded as a grateful substitute. For this reason it was formerly more cultivated in this country than now, to be eaten with salted fish during the season of Lent; and it is yet largely cultivated for the same purpose in the north of France and the Low Countries.

All animals are fond of the parsnep. To milch cows it is eminently favourable, giving a flavour and richness to their milk which no other winter vegetable but the carrot can give. The cows of Jersey and Guernsey fed with parsneps and hay, yield

butter during winter of as fine a tinge, and nearly as good flavour, as if they were fed in pastures. To horses it is equally suited as the carrot. Hogs are extremely fond of it; and, when boiled, poultry may be fed upon it.

Like the carrot, it yields a large quantity of spirits by distillation.

As a plant of agriculture, the parsnep would seem to be better suited to general cultivation in the field than the carrot, as being more productive, and having a wider range of soils; but, at the same time, from the early period at which it must be sown, from the difficulty of getting the land fully prepared for it in spring, and from the frequent failures, it cannot be said to be a plant adapted to field-culture in this country. It is, however, suited for being cultivated on the small scale, and in this view it is better deserving the attention of the cottage-gardener than other plants which have succeeded to it in common estimation.

7. The Beet.

This plant is of the natural family *Chenopodeæ*, several of the species of which are known to the farmer as weeds, while others are cultivated for their roots and leaves.

The field-beet, *Beta vulgaris*, is of larger size, and grows more above ground, than the garden kinds. It is sometimes red externally, and yellowish-white internally; but it has different shades of colour. It is frequently called Mangel-Wurzel, from the German, and has sometimes received the name of the Root of Scarcity. The introduction of the mangel-wurzel into the agriculture of this country is of comparatively recent date. It was cultivated in Germany long before it was introduced into this island.

In Belgium and Alsace, in the Palatinate of the Rhine and other parts of Germany, the most common method of culture is to sow it in beds, and to transplant it into lines. But it may be cultivated also in a manner similar to the turnip.

The land intended for this crop is ploughed before winter, and

as early in spring as the labours of the farm will allow it is ploughed across. It is then well harrowed, and rolled if necessary, and the root-weeds are collected and carried away. It is again ploughed, harrowed, and rolled, and formed into drills, if it should be in a fit state; or, if not, the ploughing and harrowing are repeated till it is so.

When it is formed into drills, the dung is carried to the land and covered by the splitting of the drills, as in the case of the potato and turnip. The quantity applied should be liberal.

The seeds are large, and stick a little together. It is therefore frequently found convenient to sow them by the hand, in the same manner as the seeds of the carrot are usually sown.

Sometimes the seeds are dibbled in, shallow holes being made for their reception by the dibble, into which a few seeds are dropped. This is a tedious process, and does not appear to possess any advantage over a continuous sowing in ruts made upon the top of the drill.

The seeds should be fresh, not exceeding one year old, and the utmost care should be taken that they are of the true kind, for great loss would be sustained should any of the smaller garden sorts be sown. The period of sowing may be about the middle of May, or earlier.

When the plants are fully above ground, the horse-hoe with coulters, or the single-horse plough, is to pass along the intervals. Immediately afterwards the hand-hoers, with the common turnip-hoe, are to thin out the plants to the distance of 9 or 10 inches.

After an interval, when the weeds are again springing up, the horse-hoe is to pass between the rows; and after this the hand-hoers are to follow, cutting up all the weeds in the same manner as in the turnip-culture.

The next process is the setting up of the earth to the roots, which may be done by the double mould-board plough. This completes the summer-culture of the beet.

Before the setting in of winter frosts, the beet may be pulled up and stored. The stems are cut off by a stroke of the knife,

care being taken not to wound the root, which is peculiarly susceptible of injury. The leaves furnish excellent food for every kind of live-stock. On the Continent it is common to cut off the leaves of this and such plants as the carrot, the parsnep, and Swedish turnip, while growing. This is a point of economy little attended to in English agriculture. With respect to the practice, it is to be observed, that in no case should it be attempted until the root has attained its full size.

The roots, when taken up, may be piled in an oblong heap and covered with straw. They should be taken out when required at one end of the heap, and this end carefully covered again with straw to exclude frost. The roots of this plant, it is to be observed, are greatly more susceptible of injury from frost than the Swedish turnip or the carrot.

Very large returns are occasionally obtained from beet, and the leaves are nutritious and wholesome, but it requires a somewhat favourable climate. It is accordingly more cultivated in the southern than in the northern parts of this island. Although in Scotland very good crops of the beet are occasionally produced, the plant is not so well suited to cultivation there as the Swedish and yellow turnips ; while in the southern counties the beet is probably a more productive crop than the turnip. Thus also, in France and the warmer countries of Europe, the turnips are not generally to be compared with the crops which are produced of beet.

The beet is well suited for feeding milch-cows, being exceedingly nutritious, and causing them to give abundant milk, while it does not taint it with the bad flavour which turnips give.

Beet is cultivated in different parts of the Continent for distillation : and in France it has been cultivated largely for its sugar.

In Mexico and South America, there are cultivated certain species of Beet, *Quinoa*, which are greatly valued for their roots, leaves, and even seeds. These kinds of beet have been partially tried in this country, and are deserving of experiment.

8. The Jerusalem Artichoke.

This plant, *Helianthus tuberosus*, is, like all the plants of the Sunflower genus, a native of the New World. It was highly esteemed by our ancestors for its tubers, but it has fallen into neglect since the more extended cultivation of the potato and other plants.

Although believed to be a native of the warmer parts of America, it is one of the hardiest of our cultivated plants, very productive, easily propagated, and growing on the poorest soils.

This plant produces stems from 5 to 10 feet in height. It does not ripen its seeds in this country, but may be propagated with the greatest ease from tubers, like the potato. It grows rapidly, and may be cultivated like the potato, but the intervals between the plants and rows should be larger. It may be planted also in autumn; but if planted in spring it will be ready in September. It is common with some to cut the stems over in July, to prevent their falling down. On the Continent the leaves and stems are used as green and dried fodder; but in England, it is believed that they have not been so employed. The tubers are in clusters attached to the roots of the plant. As compared with the tubers of the potato, they are watery, and may be believed to be inferior in nutritive properties. But the quantity is frequently very large; about 500 bushels per acre, it is said, having been produced without manure. The tubers do not seem to have great fattening properties, but they are eagerly eaten by animals.

The plant is in a peculiar manner fitted to grow under the shade. It can therefore be cultivated in woods; and it is sometimes so grown in England to afford shelter for game, the plants being left to reproduce themselves annually from tubers.

Taking into account the hardy qualities of this plant, its productiveness and easy culture, it may be doubted whether it merits the universal neglect into which it has fallen. Granting its inferiority as an article of food to the plants now cultivated for our domestic stock, it must be of some importance to have a plant

that can be so easily raised, and on soils so low in the scale of fertility. This plant, too, bears frequent repetition on the same ground.

3. Plants Cultivated for their Fibres for Thread.

1. Flax.

The plants chiefly cultivated in the north of Europe for their fibres for thread, are Flax and Hemp.

More than 70 species of the genus *Linum* are enumerated by botanists. They are of a natural order of plants, the *Lineæ*, distinguished by the tenacity of their fibres, the mucilage of their seeds, and generally by the beauty of their flowers. The most important of the genus is

Linum usitatissimum—Common Flax.

It is an annual plant, growing with a slender upright stem, branched near the top. The fibres of the bark of this plant have been applied to the making of cloth from the remotest ages.

Being a native plant, it is sufficiently hardy to endure the climate of this and other northern countries. It has, indeed, a wide range of temperature, being cultivated, and for the like purposes, from Egypt almost to the polar circle.

Flax is an exhauster of the soil and farm, and more so when its seeds are permitted to arrive at maturity. When pulled green its effects are less injurious ; in which respect it follows the general law of other cultivated plants. But still, at whatever period reaped, it is thus far an impoverisher of the farm, that its stems yield no return in manure, and that its seeds only do so when consumed upon the farm.

The soils best suited to flax are those which contain a large proportion of vegetable matter. The stiff poor clays, and the inferior soils of a very dry and gravelly nature, are not well suited

to it. The best flax-soils in England are a few rich alluvial districts, in which it is still cultivated, and where it forms a regular part of the course.

In a rotation of crops, the best period for the introduction of flax is soon after the land is broken up from grass. For this reason it may be the first crop taken after grass or clover-lea, in which case the flax is a substitute for a crop of oats in the course. But it is not necessary that flax should be grown immediately on the breaking up of grass-land. It may be sown at any period in the rotation, provided the land is in a fertile state. But in all cases it is to be regarded as an exhausting crop, and not as equivalent to a restorative one; and these principles being attended to, the period of the rotation in which flax should be introduced will be understood.

Should the soil, for example, be suited to the four years' course, the rotation may be:—1. Turnips, rape, or other green-crop; 2. Barley or wheat; 3. Sown grass; 4. Flax.

Or the order in which the flax is introduced may be changed, and the course may be:—1. Turnips, rape, or other green-crop; 2. Flax; 3. Sown grasses; 4. Oats or other corn-crop.

Under the latter course, the seeds of the clovers and grasses are sown with the flax, in the same manner as with the cereal grasses; and for this purpose the flax is equally well suited.

Flax may be sown also after a pulse-crop; but this is not usually a good preparation for flax, the land being apt to become foul when the flax is preceded by a crop of beans or pease. It is better to make it succeed either the grasses, or such crops as potatoes, turnips, carrots, beet, or rape.

It is common, indeed, to make it succeeed to a crop of corn. But this is an erroneous practice, for after a corn-crop, which has already rendered the land foul, a crop of flax tends to aggravate the evil. Sometimes, however, not only does the flax succeed a crop of corn, but is succeeded by another. This practice is opposed to all the principles of a proper rotation, and should be proscribed wherever the flax-culture is practised in this country.

In warmer countries, the flax admits of being sown before

winter, but in the north of Europe, the proper period of sowing is spring.

When land which is in grass is to be prepared for flax, it is always to be ploughed in the winter-quarter, as if it were intended for oats, and as early as convenient, so as to receive the influence of frost to pulverize it before sowing. One ploughing only is required in this case; but the land should be very thoroughly pulverized by harrowing just previous to the seeds being sown.

When flax is sown after potatoes, turnips, carrots, rape, or beet, the land is to be ploughed immediately upon the removal of the crop. One ploughing is, in these cases, generally held to be sufficient; but the land, previous to the seeds being sown, is to be well harrowed, and rendered quite smooth.

The period of sowing in this country is in the month of April, and in the more northern parts from the middle to the end of April is considered to be sufficiently early.

The universal method of sowing flax is broadcast. It might be sown, indeed, in rows like any kind of corn. But in the case of corn, the design is to produce a large quantity of seeds, whereas in the case of flax, the chief purpose is to produce long stems. And the broadcast system is better calculated to cause the plant to rise with a straight stem than the system of rows, which affords it space to branch out; for it is to be observed, that it is not desirable that the plant should branch: because, when there is a branch, the continuity of the fibre is interrupted, and more refuse is produced. When we are desirous to obtain fine fibre, we must sow thick. When we look for quantity, both of fibre and seeds, we must sow more thin. In the former case, 3 bushels to the acre may be sown; in the latter, 2 will be sufficient.

The seeds are sown by the hand in the same manner as corn. Were the flax cultivated in quantity, the broadcast sowing-machine might be substituted. Previously to sowing, the land should, in all cases, be well harrowed and rendered fine, and any stones that may have come to the surface should be removed. After the seeds are sown, they are to be covered by a double turn of light

harrows, and the land is then to be rolled and carefully water-furrowed.

In the culture of flax the changing of the seeds is considered to be beneficial and even necessary, the plant being found to degenerate when produced from seeds frequently sown on the same ground. The principal reason of this appears to be, that the plant is rarely suffered fully to mature its seeds, and its natural habits are counteracted by the closeness with which it is sown. It is from the countries, therefore, in which attention is directed to the proper ripening and preparing of the seeds, that we are indebted for our supplies. The best seeds used in this country are supposed to be derived from Holland; but the Dutch themselves obtain their supplies from Livonia, Courland, and other parts of the north of Europe, where due attention is paid to the ripening of the seeds.

When the plants of flax are 3 or 4 inches high, they are to be carefully weeded by the hand. This is generally done by persons in a sitting or kneeling posture. They advance gradually along the ridges, picking up by the hand every weed that can be observed. The young plants that have been pressed down by the weeders in this operation soon regain their upright position; but yet it is well that the weeding process be not too long delayed, lest the stems of the young plants be broken and injured.

The land, if it has been prepared in a proper manner, will not require more than one thorough weeding of this kind. After weeding, the plants will grow with vigour sufficient to overcome any common weeds that may grow amongst them.

The next process in the culture of the flax is that of reaping. This is done, not by the sickle or scythe, but by pulling the plants up by the roots.

The period of pulling the plant is determined by the principal end in cultivating it. When it is wished to procure fine fibre, the plant should be pulled when somewhat green. When it is wished to procure the seeds either for sowing again or for crushing for oil, the plants must remain until the seeds are ripe. This will be denoted by the hardened state of the seed-vessels, the yellow

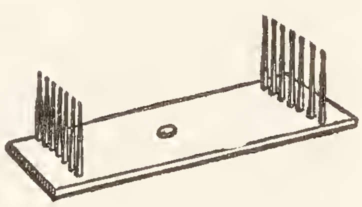
colour of the stems, and the falling off of the leaves. When flax of good quality, but not extreme fineness, is wanted, the best period for pulling is just when the plant has attained its maturity with respect to the formation, but not to the full ripening, of the seeds. When it is required for the finest fabrics of all, as for cambrics and muslins, it should be pulled when it begins to flower.

When the crop is ready, the plants are pulled up by the roots, and laid in handfuls alternately crossing one another, and left upon the ground for a few days to wither. They are then freed from the capsules or seed-vessels, and made into small sheaves, which are conveniently tied by a few stems of the plants themselves, or by some rushes or thin straw-ropes.

The separation of the seed-vessels from the stems is performed by a process termed rippling.

The rippling machine is an implement like a comb, with iron teeth fixed upon a plank. Through these teeth the stems are repeatedly drawn by the hand, and thus the capsules or seed-vessels are separated. The ripple is placed in the middle of a large sheet of canvass spread upon the ground. There may be two sets of teeth, as shewn in the figure, fixed on one plank, so that two persons may work at the same time; and the plank may be conveniently fixed in the ground by a pin passed through it. The capsules are preserved, the seeds being either used for sowing, or bruised for oil.

Fig. 186.



The next process is to separate the fibres from the stem. The common method of doing this is by steeping the whole plant in water. By this means the softer part of the stem partially undergoes the putrefactive fermentation, while the tougher fibres of the bark are not affected. At a certain period, then, as ten or twelve days, before the fibrous part of the bark has become affected, the plants are removed from the water and dried. After being dried the stems become brittle, and are easily separated by rubbing or beating from the fibrous part of the bark, which is the only part employed in the manufacture of linen. It will appear that, if the

putrefactive process shall proceed too far, the fibrous as well as the more mucilaginous part of the bark may be affected. It is, therefore, a point of practice, to allow the putrefactive process to proceed just the length of affecting the softer part of the stem, without acting upon the fibrous part of the bark. And the usual manner of performing the process of steeping is the following :—

The little sheaves made up after the process of rippling, are carried away to a pool or tank, either containing water, or into which water may be conveyed : and in all cases the water ought to be soft.

The sheaves should be built in the pool in a nearly upright position, the heads of them being uppermost. They are then kept under water by stones or heavy substances of any kind, in such a manner as that they shall not rise to the surface. They must not, however, be compressed to the bottom, but merely so loaded as that they shall be kept below water.

The period of steeping to the proper point must be carefully watched. In warm weather eight days will sometimes suffice, in other cases ten or twelve. After the sixth or seventh day, the state of the flax must be observed from time to time. It is safer to steep it too short a period than ever so little too long. In the first case, merely a little more time is required in the future processes ; in the second, the strength and texture of the fibres may be injured.

When the flax is found to be sufficiently steeped, it is taken from the pool sheaf by sheaf, and laid in heaps near the watering-place until the water has drained off. It is then carried away to a dry and airy grass-plot. Here the sheaves are opened out and spread thinly and evenly in rows upon the ground, the spreaders working backwards, and causing the but-ends of one row just to touch the tops of the next, so that the whole plot of ground shall be covered with a thin coating of flax.

In this state the flax is allowed to lie for a time, determined by the state of the weather, generally ten or twelve days, and sometimes more.

During the further process of rotting, or *dew-rotting* as it is

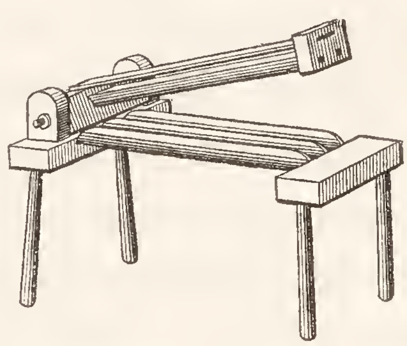
termed, the dissolution of the soft part of the stem is still further promoted, and the whole becomes hard. When it has lain for a sufficient time, which is known by its being brittle when rubbed, and when it is at the time sufficiently dry, it is bound up again into sheaves, but larger than those made before the watering process. It is allowed to remain in these sheaves a little time to dry, after which it is carried home.

These are the common operations of the culture and preparation of the flax, but variations in practice take place; and in an especial manner, the steeping of the stems is superseded by chemical processes.

The carrying home of the flax terminates the preparation, in so far as the mere grower is concerned. The remaining parts of the operation are properly the province of the manufacturer. But sometimes the manufacture proceeds on the farm itself to the extent of partially separating the fibrous part.

The first process in this case is breaking the stems, which is usually done by an instrument called a *break*. This machine consists of three triangular planks, fixed together at both ends. Two triangular planks are fixed to another frame. The two frames are fixed together at one end by a hinge, and work the one into the other, as in the figure.

Fig. 187.



The upper moveable frame being lifted up, handfuls of flax held in one hand are placed upon the lower frame, while with the other hand the upper frame is made to work upon the flax by repeated strokes. In this manner the flax is bruised, and put into a state to have the ligneous refuse separated from the fibrous part by beating or scutching.

Scutching may be performed either by machinery or by manual labour. When performed by manual labour, handfuls of the flax being suspended by one hand over a plank are beaten by a flat piece of wood held in the other hand. By repeated strokes, the woody refuse of the stem is separated from the fibrous part

of the bark. But the operation of scutching is now very generally performed by machinery, the raw material, after being bruised by the break, being sent to the lint-mill for that purpose.

To complete the process, and to get the fibres sorted into lengths, so as to be fitted for spinning, the lint goes to a class of persons whose business it is to give it this final preparation. These are termed hecklers. The heckler operates by means of a set of numerous teeth, placed vertically upon a board. The flax is pulled repeatedly by the hand through these teeth. In this way, and by using heckles of different sets of teeth, the workman sorts the lint into lengths. The refuse after this operation is tow.

The produce of flax varies greatly with the seasons, soil, and management. It may be said to be from 30 to 60 stones per acre, that is, after being scutched, and before being combed or heckled.

Besides the produce of the plant in lint, that of its seeds is of considerable importance. The quantity of seeds produced on the acre varies as greatly as that of the produce of the stem. It may be said to be from 6 to 10 or 12 bushels to the acre.

The seed is frequently divided into three sorts; the first sort is reserved for seed, the second for bruising for oil, and the third, or refuse, is employed at once for the feeding of cattle.

The capsules containing the seeds, we have seen, are separated by the ripple. The ripple is carried to the field, and the operation takes place before the handfuls of the flax are bound into sheaves, to be carried to the watering-pool.

The capsules are then dried in the sun, during which a number of them will open, and allow the seeds to escape. These are the best and ripest, and may be reserved, if so wished, for sowing.

The remaining seeds are separated from the capsules by a slight beating. The seeds are then carefully sifted and winnowed, and laid in some properly ventilated place, care being taken to turn them from time to time.

The expression of the oil by bruising is a sufficiently simple process, and is done by machines more or less perfect.

The refuse of the seeds may be given to live-stock. They are

highly nutritive in every form. They are frequently given boiled to young animals, as calves, and to sick horses and cows. By the process of boiling, a jelly is formed, which all herbivorous animals will eat. It is for this purpose that the refuse of the seeds of the flax, which are not sufficiently good for crushing, is often reserved.

The culture of the flax does not extend in this country, and has generally decreased as improvements in agriculture have advanced. This arises, in part, from the nature of the plant, the minute care necessary in its culture, and the large supply of extraneous manures which it requires. It arises, however, also, in a great degree, from the extended commercial relations of England, which enable her to obtain the quantity of the raw material required from countries better fitted to produce it, or where the comparative expense of labour is less. Flax, it has been said, requires a large proportion of vegetable matter in the soil. Sometimes, for this reason, peaty soils will produce it in great abundance; but the best flax-soils are those rich vegetable grounds which exist in new countries, as over all the temperate parts of America, and even in the north of Europe, and chiefly upon the flat margins of rivers enriched by deposits of mud. These are the great flax-soils of the world, and may supply this country with the material, for the uses of the arts, in any quantity that may be required. The best cultivators of flax in Europe are the Flemings, amongst whom the linen manufacture took early root, and who have ever since pursued the culture of flax with diligence and success.

2. Hemp.

Hemp, *Cannabis sativa*, is of the natural order *Urticeæ*, the Nettle tribe, many of the species of which, like the hemp, are remarkable for the tenacity of their fibres. Even the common nettle, familiar to the farmer as a weed, possesses this property.

The hemp is supposed to be of Eastern origin. It is very gene-

rally diffused over the world, and has been used for supplying cordage and cloth for a period unknown.

The hemp is a fine and graceful plant. It is diœcious, that is, the male and female flowers are produced on different plants. It grows with us, in the fields, to the height of 5 or 6 feet,' but in the richer soils of warmer countries it attains to a much greater elevation. In the fertile plains of Lombardy, it rises to the height of 12 feet or more; and, mingled with the maize and other cultivated plants, gives an air of surpassing richness to the landscape.

The leaves of the hemp are powerfully narcotic; its seeds are nourishing, and are eagerly consumed by birds; and they produce an oil which is used for many purposes of the arts.

But the great use of hemp is for the making of cordage and canvass. For this, its tough, durable, and elastic fibres are suited beyond any other substance. The supply of hemp for the cordage and canvass of the shipping of this country is immense, and forms a vast trade with the ports of the Baltic. But, besides being used for the canvass of sails, sacks, and other coarser fabrics, hemp is employed in forming numerous cloths used in domestic economy, as towels, coarser table-cloths, and the like.

Hemp, like flax, prefers a rich vegetable soil, but it is not at all nice in the choice of soils, growing in clay, sand, or peat, provided merely the land is kept rich with manures. Hemp, too, possesses the property of growing upon the same spot for successive years without degeneracy.

For hemp the land may be prepared in the same manner as for flax. But hemp, unlike to flax, may precede or follow a crop of corn in the rotation; and the reason is, that while flax invariably renders the land more foul, the tendency of hemp is to smother and choke all other plants. Grass-seeds, too, cannot be sown with hemp, because they would be destroyed under the shade of its thick foliage.

Hemp may be introduced into the rotation in such a manner as the following:—1. Fallow or green crop; 2. Wheat; 3. Sown grasses; 4. Hemp; 5. Oats. Or, 1. Fallow manured; 2. Wheat

or other corn-crop ; 3. Sown grasses; 4. Oats ; 5. Hemp manured ; 6. Corn-crop. Or, in very rich soils, hemp may follow hemp, provided the land is largely manured every second year.

The land intended for hemp should always be ploughed in time to receive the influence of frost ; and when it follows a corn-crop, besides a deep ploughing before winter, it should receive two or more ploughings in spring, so as to reduce the soil to a fine tilth, and free it of root-weeds.

The period of sowing hemp is later than that of sowing flax, for it is more easily injured by the frosts of spring. It may be sown towards the end of April, or beginning of May.

The best seeds are held to be those obtained from Riga ; but wherever the seeds are procured, care must be taken that they be fresh, which will be known by their being heavy and bright in the colour.

The quantity of seeds sown to the acre is generally from 2 to 3 bushels, and the common method of sowing is broadcast. But hemp is well suited to be sown in rows, this method of cultivating it presenting the advantage of allowing the intervals to be well tilled, and of admitting air to the plants.

The distance between the rows may be 30 inches. The horse and hand hoe may be both employed. In the first hoeing, the plants should be hoed out to the distance from one another of a foot in the rows, and after the interval of a month or six weeks, another horse and hand hoeing should be given, which will complete effectually the summer culture of the hemp.

But the common practice in the hemp districts is to sow broadcast, hoeing the plants to the distance from one another of a foot or 16 inches, and giving another hoeing after an interval of a month or six weeks. There are other districts, again, in which it is common to give no other culture than to pull up the larger weeds, trusting to the rapid growth of the hemp to overtop all kinds of plants.

As the season advances, the hemp grows with great rapidity, and in autumn it is pulled up. But the circumstance of the male

and female flowers being on different plants gives rise to a peculiarity in the method of treating the hemp which exists in the case of no other of our cultivated plants.

The male plants are distinguished from the female by their producing numerous flowers. These, after they have stood sufficiently long to discharge their pollen, are pulled up, the female plants being allowed to stand for several weeks longer, to ripen their seeds. The period of pulling the male plants is generally five or six weeks before pulling the female or seed-bearing plants. Thus there are two harvests of the hemp, the one five or six weeks before the other.

When the period of pulling the male plants arrives, which is denoted by the forming of the seed upon the female plants, the pullers walk between the drills, when the row-system is adopted, and, when the broadcast is used, in the furrows between the ridges, and stretching across, pull up the stalks, taking care not to tread upon or break down those that are to remain. The male plants are easily known at this time by their yellowish colour and faded flowers. When pulled, they are tied in small bunches, previous to being carried to the pool to undergo the process of steeping, as in the case of flax.

The second pulling takes place when the female plants have matured their seeds. This is known by the brownish colour of the capsules, and by the fading of the leaves.

The plants are then bound in bunches and set up on end to dry, in the same manner as sheaves of corn. When the whole are so dried that the capsules can be easily rubbed from the stalk, the sheaves are slightly thrashed, and thus the capsules are separated from the stems.

When this is done, the plants are taken in small bunches to the pool to be steeped.

The male plants, we perceive, undergo the process of steeping before the female plants. The manner of performing it is in both cases the same. But often the female plants do not undergo the process of preparation in the same year, but are stacked, so as to be prepared in the following spring and summer.

As it is in some cases necessary to economize the water used for steeping, the water of one pit or pool is made to serve the purpose of successive waterings. Sometimes five waterings take place in the same pool; but there should not, if possible, be more than three without the admixture of fresh water, since the fresher the water is the better.

The bunches are generally placed in the pool in rows, crossing one another, and pressed down by some heavy substance laid upon them, so as to be kept from rising to the surface, care being at the same time taken that they are not so loaded as to be forced down to the bottom. If the weather be warm, four or five days will frequently be sufficient; if not, two or three more; but the period is denoted by the stem being so softened that the outside coat shall come easily off. Care must be taken, as in the case of flax, that the putrefactive process does not proceed so far as to injure the cortical fibres. The quantity put into one pool may be the produce of an acre; but it is better that the quantity be small and the pits shallow.

When the hemp is thus steeped, it is, like flax, taken out of the pool and carried away to a plot of sward, on which the plants are spread singly and regularly.

The hemp thus spread out, lies three, four, or more weeks upon the surface, and is turned over not less than twice a-week. It is thus subjected to the further influence of the rains and dews, and the decomposition of the ligneous part of the stem is promoted. By this process the stem becomes hard and brittle.

When the hemp is seen to be in a fit state for removal, it is taken from the ground, bound into bunches, and carried home to the barn, where it undergoes the process of bruising by the machine called a break, as in the case of flax.

When thus prepared it is bound up in bunches, generally weighing a stone each, and carried to market. The hemp which breaks off in the operation is technically termed shorts; and is half the value of the long hemp. The refuse is used as fuel.

Often the steeping process or water-rotting is omitted, and the hemp is simply dew-rotted. Thus, when the female plants are

not immediately prepared, but are dried and stored up during winter, they are not put into the steeping pool, but spread on the sward early in the next season, as in January or February, regularly turned, and exposed for a sufficient time to the influence of the weather. In this manner the necessary decomposition of the stem takes place; but it is always better to hasten the fermentative process by steeping, the texture of the hemp being injured by too long exposure.

After the hemp has undergone the operation of breaking, it passes into the hands of various artizans.

The first operation is that of heckling, which is done either by the hand or by machinery. The hemp is first beaten, and then dressed by means of fixed heckles, resembling those used for flax. It is arranged into sorts, finer or coarser, to suit the demands of purchasers. It then passes into the hands of the spinner, of the whitster, as he is called, of the weaver, and of the bleacher.

The produce of hemp in rough fibre, that is, before heckling, varies from 30 to 50 stones and upwards per acre. It leaves a large return when the crop is good, but the expense of labour in all cases is considerable.

The quantity of seeds produced is not less various than that of the fibre; 10 or 12 bushels to the acre are considered as a medium produce, but this quantity is often considerably exceeded.

It is a question in the case of hemp, as of flax, how far it is expedient to extend its cultivation in this country. In many cases, certainly, hemp might form a profitable subject of culture. It is held to be a good paying crop in the districts where it is yet raised, and in many cases the value of the first crop of hemp raised from peaty soils might be found to be more than the fee-simple of the ground. But yet, as an object of general culture, it does not appear that much public or private benefit would result from an increase in the production of hemp. It is a plant that requires a large supply of manures, not always easily obtained, and a degree of minute labour not always consistent with the regular business of a well-ordered farm. It can be obtained,

too, in unlimited quantity from other countries; and it appears that the home cultivation of it has diminished as the commercial relations of the country have been multiplied and extended.

Of the textile plants of Northern Europe, greatly the most important are the flax and hemp.

Numerous plants, however, yield fibre of sufficient tenacity for forming threads. Some of these have been partially cultivated, or made the subject of experiment.

Many of the Nettle tribe, as well as the hemp, yield tough and durable fibres. The Common Nettle, *Urtica dioica*, might be used for this purpose.

Urtica nivea, the Chinese or White-leaved Nettle, is a native of China, Japan, and other countries of the East, where it is used for making cordage, and sometimes thread. No satisfactory experiments are recorded of the culture of this plant in Europe.

The Siberian or Hemp-leaved Nettle, *Urtica cannabina*, is a native of Siberia, whence its seeds were brought to St Petersburg, and dispersed over Europe. No conclusive experiments upon it, as the subject of culture, seem to have been made.

Urtica canadensis, and others of the genus, have been proposed for use; but experiments upon them as the subjects of useful culture, are entirely wanting.

The Hop, *Humulus lupulus*, which is of the Nettle family of plants, likewise yields tough and durable fibres, but the fibres are with difficulty separated from the stem, and the plant is never cultivated for this purpose.

Asclepias syriaca, Syrian Swallow-wort, is one of the textile plants. It is a native of Canada, though termed Syrian. In Canada it fills the woods with its fragrance when in flower. Its seeds are surmounted by tufts of silky down, which can be used like cotton. This plant, though long known in England, has never been cultivated for economical uses. It is perennial, and may be planted in rows. Its habit is to send forth numerous shoots, and in the third year these will have covered all the ground. Independently of the down of its seeds, the bark of the

plant yields fibres like the hemp, and, it is said, more abundantly. It has been partially cultivated in France, in some parts of which it may be said to be naturalized. Its cultivation has made some progress in Silesia. How far it could be advantageously introduced into the agriculture of the north of Europe is not yet known.

Various common plants yield fibres of sufficient toughness to be made into thread; as the Esparto Rush, *Stipa tenacissima*, which is used in Spain for obtaining coarse thread; the Common Broom, *Cytisus scoparia:* the Spanish Broom, *Spartium junceum :* the Hemp Marsh-Mallow, and other Malvaceæ; different species of Aloe, and several plants of the Lily tribe.

Phormium tenax, Iris-leaved Flax-lily, sometimes termed New Zealand flax, has recently attracted attention for the uses of its fibres. This plant grows with broad, stiff leaves, like plants of the Lily tribe. It is found in New Zealand and Norfolk Island, where its fibres are converted into threads, fishing-lines, cloth, and mats. It has since been used for cordage for ships, and it is found to be well suited for the purpose; and it has recently been manufactured into various coarse fabrics in this country. It has been long grown in gardens in England; and, in the south of Ireland, some attempts were made to cultivate it for use. The iris-leaved flax-lily, however, requires a warmer temperature than we possess in these islands.

The warmer regions of the world abound in plants possessing a fibrous structure of the bark, which renders them capable of being employed in the making of ropes, thread, and cloth.

Other plants, of various families, produce a down which envelopes their seeds. Of these, greatly the most important, and now an object of vast consumption, is the Cotton plant *Gossypium*. This is the plant of warmer countries, and can only be known in the colder parts of Europe as the subject of commerce. The warmer parts of the temperate zone, and also the intertropical regions of America, Asia, and the accessible parts of Africa, can furnish us with the down of the cotton seeds in unlimited quantity.

Several native plants furnish a pappus or down which may be converted into cloths. The down of some kinds of *Eriophora*, or Cotton-grasses, the produce of our bogs and heath soils, has been manufactured into cloth, and exhibited in the country as curious native productions; but no economical benefit can result from the use of these substances.

4. Plants Cultivated for their Oils.

The plants usually cultivated in the north of Europe for their oils, are—

1. The Rape, and other plants of the Cabbage genus.
2. The Mustard, the Radish, the cultivated Camelina, and other Cruciferæ.
3. The Hemp and Flax.
4. The Poppy.

The oils which these plants yield are obtained by bruising their seeds, and are termed Fixed Oils. There is another class of oils obtained by distillation, termed Volatile Oils. These last are yielded in an especial manner by plants of the Mint family; but the plants producing them are rarely the subjects of cultivation on the large scale.

Of the oil-bearing plants of the north of Europe, the most extensively cultivated are the fusiform varieties of the genus Brassica, namely,—

1. Brassica Napus—Rape or Cole.
2. Brassica campestris—Navew, Rape or Colza.
3. Brassica Rapa—Turnip.
4. Brassica præcox—Early Cole.

The two last-mentioned species are only partially cultivated for their oils; the two former are regarded as the most important of our oleaginous plants.

The manner of cultivating these plants for their leaves has been described, and there is no other difference in the manner of cultivating them for their seeds, than suffering them to stand un-

til they are ripe. The turnip and early cole will usually ripen their seeds in the same year, and so will the other species, if sown sufficiently early, and if the produce of spring-sown seeds is sown; for these, like other cultivated plants, acquire the habit of late or early ripening, according to the period at which they are habitually sown. The proper period, however, of sowing the seeds of the rape in this country is in summer or autumn, that they may ripen their seeds in the following summer. They are to be kept clean by horse and hand hoeing in the first year; they will be in flower in the May of the following year, and in July the seeds will be ripe.

The plants are best reaped by the sickle, and the operation is to be performed with care, so as to prevent the loss of seeds by shaking. The plants may be bound into bunches, and placed in stacks until it is convenient to thrash them. But it is better to thrash them as soon as they are dried. This may be done in the field, if the weather is good, by thrashing on boards, with sheets of canvass spread underneath; or the crop may be carried home to the barn and thrashed there. The seeds are easily disengaged from the pods, and the most suitable instrument for the purpose is the flail.

The dried stems are of little value. They are sometimes given to cattle in place of straw; but it is better that they be employed only as litter, and so made into manure. They are sometimes burned for the potash they contain.

The seeds are spread for a time upon the granary floor, not less than several weeks. They are then bruised in mills of different construction.

The mill used for the bruising of the seeds of this and other plants for oil, is in most parts of Europe a very simple machine, consisting merely of a millstone placed vertically, and moved round by a horse or mule in a circular trough. The seeds being placed before it, it crushes them, and so the oil is expressed. More perfect mills, however, are employed, and perform the work by stamping. In Holland, the Netherlands, and part of Germany,

where the culture of the oil-plants is extensively practised, it is common to have an oil-mill attached to the farm. In England, the seeds of the oil-plants are always sent to the oil-manufacturer, the preparation of the oil forming a distinct profession.

The refuse, consisting of the husks after the oil is expressed, is rape-cake. This being ground, forms the manure called rape-dust.

Besides the rape and other species of cabbage, the plants of the *Sinapis* or Mustard genus, and of the *Raphanus* or Radish genus, yield oils from their seeds, and may be cultivated for that purpose.

Of the genus *Sinapis*, either the white or the black species may be sown. The black mustard, *Sinapis nigra*, is the species usually cultivated for the well-known condiment mustard. But the white species, *Sinapis alba*, is rather better suited for the production of oil, it being more productive of pods, and less subject to injury from insects in the early stages of its growth. Either of these species may be sown in March or April, and in July or August the crop will be ripe. They are easily cultivated, but they are apt to spring up again from seeds that have not vegetated in the first year.

The *Raphanus*, or radish, is equally suited to yield oils as the mustard. The common radish, *Raphanus sativus*, is well known as a salad. It should be cultivated, as all such plants should, in rows; and, as it spreads over a considerable space, sufficient room should be given to it. It flowers and bears seeds for a long time during the season, but no difficulty exists in knowing the proper period for reaping it. A variety, derived from China, has been supposed to be more productive of seeds than that in common cultivation, and has been accordingly termed *Raphanus sativus oleifer*.

The mustard and the radish have this superiority as oil-plants over the rapes commonly cultivated, that they are sown and reaped in the same season. The quality of the oil is nearly equal.

But these plants are never cultivated on the large scale in Eng-

land. They are, however, supplied in considerable quantities to the oil-manufacturers by nurserymen, who dispose of their spare produce in this manner. Even the wild mustard and wild radish, plants which sometimes spring up in vast quantities in our cultivated fields, yield seeds which produce oil; and sometimes the produce of these destructive weeds may in this manner be turned to account.

Almost all cruciferous plants yield more or less of oil. One of these, *Camelina sativa*, cultivated Camelina, is a plant produced in various parts of Germany and Italy for this purpose.

This plant is, like the last-mentioned species, an annual, and is raised with facility. It grows spontaneously over a great part of Europe, and is a frequent weed amongst flax. It grows best on light sandy soils, and in the south of Europe two crops of it can be produced within the year. The oil it produces is said to be fine in quality, retaining a good flavour, and in burning it does not produce any disagreeable odour. In the south of Europe it is sown in April or May, and is sometimes ready in less than three months, so that it is one of the quickest growing of the oleaginous plants. The seeds are sown thin, and the plants hoed if too thick. It is pulled or cut, and laid in a covered place to complete the ripening and drying of the seeds. These being then freed from the stalks by beating, are winnowed, dried, and bruised.

Linum usitatissimum, flax, yields an oil by expression, which is greatly used in the arts. But it is cultivated at the same time for its fibres; and for obtaining its oil it is merely suffered to stand until its seeds are matured. The manner of separating the capsules which contain the seeds from the stems, has been described. The seeds are bruised in the same manner as those of the other oleaginous plants. The refuse after expression is termed *oil-cake*, and forms a nutritive food for cattle.

The seeds of the hemp, in like manner, yield oil, which is employed for nearly the same purposes as the oil of flax. The hemp, however, being diœcious, only part of the crop yields oil, namely, the female or seed-bearing plants.

The Poppy is cultivated in various parts of Europe for its oil. The oil of the poppy is sweet, and well suited for domestic uses. It is esteemed to be the next in quality to that of the olive.

Any of the species of *Papaver* will yield oil. But that which is generally cultivated in Europe for this purpose, is one or other of the varieties of *Papaver somniferum*, the sleep-bringing or opium poppy.

The soil for the poppy requires to be well pulverized and manured. In the parts of Flanders where it is cultivated, this point is especially attended to. It frequently succeeds rape in the rotation, manure being applied to both crops. It should be sown early, as in March or April, cultivated in rows, and the plants thinned out to 6 or 8 inches distant. The mode of reaping it in Flanders is peculiar. Sheets are laid along the line of the standing crop, upon which the reapers, gently bending the heads forward, shake out the seeds from the capsules. When no more seeds will fall from the capsules, the row is pulled up and placed in upright sheaves, in order to allow those capsules to ripen which had not at first yielded their seeds. The sheets are then drawn forward to the next row, and so the process is continued throughout the field.

Some plants of the natural family *Compositæ* yield seeds which will produce oils by expression. One of these, *Helianthus annuus*, the Sunflower, has been cultivated in some parts of Europe for this purpose. This plant, a native of America, and familiar to us as a garden flower, is easily cultivated. But it does not rank high as an oil-bearing plant, and its seeds are more usefully employed for the feeding of domestic fowls. Another plant of the same family, *Madia sativa*, likewise a native of America, has been recently cultivated in Europe for its oil, and the result of the experiment is said to have been favourable.

Several of the natural family *Umbelliferæ* may be also cultivated for their oils. One of these is Coriander, *Coriandrum sativum*, a plant which is, however, more frequently cultivated for the aromatic flavour of its seeds.

Of the trees whose fruits or seeds yield oils, the most important is the Olive, derived originally, it is believed, from the East, but now cultivated on all the shores of the Mediterranean, and the southern countries of Europe. The oil of the olive is obtained in small quantity from its seeds, but chiefly from the pulpy substance of its fruit.

The Almond is a tree yielding oil of high estimation, but its cultivation is confined to the warmer countries. Proceeding northwards, the olive is succeeded by the walnut, the beech, and the hazel. The oil of these plants is obtained from the seeds, and is sometimes mixed with and sold as the oil of the olive.

The warmer regions of the world abound in plants producing oils; such is *Ricinus communis*, the Castor-oil plant, which is also cultivated in the south of Europe. There, however, it is only an herbaceous plant; but in Africa and the warmer parts of America, where it is largely produced, it is a tree. In the Brazils it affords the principal part of the oil consumed in lamps.

Another of the oleaginous plants of warmer countries is *Arachis hypogæa*, American Earthnut. This plant is remarkable for ripening its seeds under ground. It has been cultivated in the south of Europe; and with some care it has been made to ripen its seeds in the latitude of Paris, and is grown abundantly in the Southern United States of America.

Another of the oleaginous plants is *Sesamum*, Oily Grain, of which there are several species. Oily grain is one of the principal herbaceous oil-plants of Africa and eastern countries. It was an oil-plant of the ancient Jews, as it still is of their descendants, of the Arabs, and of other Eastern nations. In Asia, it is the most generally diffused of all the oleaginous plants. It is grown in the south of Europe, but is unfit for cultivation in higher latitudes.

The growing of the oil-plants forms an important part of the agriculture of many countries. In England the cultivation of these plants is regarded as of minor interest, and is little practised; not because oil is little consumed in England, but because that which

is required for domestic purposes and the arts can be derived from other countries by commerce.

5. Plants Cultivated for their Dyes.

The plants chiefly cultivated in the north of Europe for their dyes are:—

1. Isatis tinctoria—Woad.
2. Rubia tinctorum—Madder.
3. Reseda Luteola—Weld.

Isatus tinctoria, Woad, is indigenous in various parts of Europe. It is one of those plants which yield the deep blue colouring matter so greatly valued in the arts, Indigo. It was in extensive use in Europe previous to the introduction of the indigo of commerce, which is derived from the green parts of certain species of *Indigofera*, the production of warmer countries.

Woad is a perfectly hardy plant, and in this climate is a biennial. Its seeds may be sown early in spring, in which case a certain produce of leaves may be obtained in the same season; or it may be sown in summer or autumn, when the return is obtained in the second year.

The plant requires a deep rich soil, perfect preparation of the ground, and a careful tillage during the period of growth. It is best cultivated in rows, at such distances from one another as to admit of the operation of the horse and hand hoe. It is usually grown on a flat surface, although it may be cultivated in raised drills in the same manner as turnips. When the leaves are of their full size, and before they have begun to change to their paler colour, they are picked off by the hand; and in this manner successive crops are obtained during the season; and when the plants have shot forth their flowering stems in July or August, the land is ploughed and prepared for another kind of crop.

The leaves, when collected, are washed, and, being dried, are carried to a mill similar to that used for bruising the seeds of oil-plants. The paste obtained is placed in heaps and fermented,

and the heaps are then broken down and formed into balls, which are the subject of commerce: or else the paste is first formed into balls, which are dried in proper apartments; and to fit these balls for the dyeing process, they are reduced to powder in the same mill which had been employed to form the paste. The ground material is then spread 3 feet deep on a floor, moistened with water and slowly fermented. Being then gradually cooled, it is ready for being stored in casks, or otherwise preserved until required for use.

The colouring substance may also be obtained, like that of the indigo plant, separately from the leaves. This is done by fermenting the leaves in water, and extracting the colouring substance from the green part of the plant. The process is described in a work drawn up by the French Government in 1811, at which time the cultivation of woad was a favourite object with Napoleon, in his endeavours to find substitutes for the colonial produce of other countries. This method of preparation, however, does not seem to have been extended; and less artificial processes prevail where the woad-culture is practised.

The culture of woad, and the preparing of the leaves, require a minute care scarcely compatible with the regular business of the farm, as practised in this country. But the yet greater objection to its more extended culture is the uncertainty of the returns, arising from the competition of the indigo of commerce, which can be obtained in great abundance from the intertropical countries of Asia and America.

The next of the common dye plants of Europe is Madder, *Rubia tinctorum.* This plant has an annual stem, but it is from the root that the dye is produced. Like others of the family to which it belongs, it tinges with red the milk, the urine, and the bones of the animals that feed upon it.

The root is composed of long succulent fibres, which strike deep into the ground. The plant is best raised from sets, and should be cultivated in rows with a good distance between. The method of the drill turnip-culture seems entirely suited to the habits of this plant; and doubtless in this manner it could be

successfully raised. The roots are taken up before winter in the third year, at which time, if the soil has been suitable, they will be frequently found extending from 3 to 4 feet deep in the earth. The proper kind of soil for this plant is a deep sand.

The roots, when taken from the ground, are dried by a moderate heat, and then pounded by stampers. The first beating separates an inferior kind of madder mixed with impurities; the second beating a medium sort; the third is the interior and brighter part of the roots, called in this country *crop*-madder. The dye thus produced is a peculiar red, and is a substitute for cochineal.

Holland was long the country from which we derived our supplies of madder, and the plant is still much cultivated by the Dutch and Flemings. It can be readily raised in England, for it is not a plant of difficult culture; but experience has shewn, that it can be produced more cheaply in countries where the climate is more favourable, and the cost of production less.

Weld, or Dyer's Weed, *Reseda Luteola*, is another of this class of plants. It is of the Resedaceæ, or mignonette family. It is a native, and generally a biennial. It is found in earth brought from a great depth, as the rubbish of coal-mines.

Weld affords a fine yellow dye for cotton, wool, silk, and other substances. Weld and the bark of the *Quercus tinctoria* yield the principal yellow dyes employed in the arts; but the latter is now in the most general estimation in this country.

Weld is the most easily cultivated of all the dye plants, growing on a variety of soils, without requiring one of great fertility. It may be cultivated in the same manner as the clovers and common grasses, that is, it may be sown with any crop of corn, and reaped the following year. In this manner it is sometimes cultivated, being mixed with the clovers and grasses, and plucked up from amongst them when it is in flower.

But the surer method of cultivating the weld is by itself, in which case it may be sown, in the month of May or later, broadcast or in rows. The surface of the ground should be well smoothed, and the seeds, which are very small, lightly covered. The plants are to be carefully cleaned during the period of their

growth, and in the month of July in the second year they will be in full flower, and then they are to be pulled up, without waiting for the ripening of the seeds.

The plants are pulled up by the roots, and set upright, generally four together, to dry. When they are sufficiently dry, which will be in the course of a week or more, they are bound into larger bundles, in which state they are ready for sale; or they may be stacked, and preserved for years without suffering injury. The culture of the weld, therefore, differs from the other dye plants in this, that no part of the preparation of the dyer falls upon the grower. The dye, when extracted from the stalk, must be soon used, otherwise it will ferment and become useless.

The produce varies greatly with the seasons, being from 12 to 40 cwt. of stems or more to the acre. It sometimes yields a good profit, but the demand for it is very uncertain. It is exceedingly subject to a species of blight. Coupling this with the unequal demand, little advantage seems likely to be derived from the more extended culture of it in this island.

The woad, the madder, and the weld, are the plants usually cultivated on the large scale for their dyes in the north of Europe. But innumerable other plants yield those beautiful substances, and are partially cultivated:—

1. *Crocus sativus*, Saffron Crocus, an autumnal species of a genus known to us as yielding amongst the earliest of our vernal flowers. The plant is cultivated from bulbs. The dye produced is saffron, and it is derived from the stigma and style of the plant. The colour of the crocus, however, is very fugitive, being obliterated by the action of the solar rays.

2. *Carthamus tinctorius*, Bastard saffron or safflower. It is the flowers of the plant which are used for dyeing. The dye produced is of two kinds, a yellow and red. The yellow is separated by maceration in running water. The remaining dye is a delicate red, more beautiful even than cochineal, but it is little permanent. When ground with pure talc, it forms the kind of

rouge termed by the French *rouge végétale*. The seeds yield also an oil, which is used in medicine and painting. The plant is cultivated in various parts of Europe, and extensively in Egypt and the Levant, whence great quantities are imported into England for painting and dyeing.

3. *Nerium tinctorium*, Dyer's Oleander, one of a genus of beautiful evergreens, yields indigo, and it is believed might be cultivated for that purpose.

4. *Galium verum*, Lady's bedstraw, a familiar plant of the natural family *Rubiaceæ*, and yielding, like the madder, a red dye.

5. *Rhamnus infectorius*, Yellow-berried buckthorn, the fruit of which produces a yellow dye, is cultivated in France under the name of *Graine d'Avignon*. The dye is extremely fugitive.

6. *Croton tinctorium*, Officinal Croton, yielding a beautiful blue, which is employed to dye silks and wools. This substance is known to us under the name of Turnsole.

A vast number of other plants could be enumerated as yielding dyes, and capable of being cultivated for that purpose. The colours they yield are more or less valued for their permanence and beauty.

6. Plants Cultivated for their Sugar.

Of the plants which are either cultivated, or which admit of cultivation, for their sugar, the following may be enumerated :—

1. Beta cicla et vulgaris—White and Common Beet.
2. Brassica Rapa, Solanum tuberosum, Pastinaca sativa, and other plants producing tubers and mucilaginous roots.
3. Vitis vinifera, and other species of Grape.
4. Betula alba—The Birch.
5. Acer saccharinum—The Sugar-Maple.
6. Saccharum officinarum—The Sugar-Cane.

The Beet has been cultivated largely in France for its sugar.

The sugar produced can be crystallized, and is then little inferior to that derived from the sugar-cane ; but it cannot yet enter into competition with the latter with respect to cheapness of production. The manufacture in France owed its origin to the rude plans of Napoleon, to render his empire independent of the sugar of commerce, and is now only maintained by a system of fiscal regulations, which exclude, or admit only, on unfavourable conditions, the produce of the sugar-plants of the tropics.

Although, under the artificial system by which it is supported in France, the manufacture of the sugar of beet cannot be regarded with favour, yet it is of great interest and curiosity, as evincing the large quantity of sugar which exists in certain vegetables, or the facility with which their constituent parts may be converted into this nutritive and grateful substance.

Besides the beet, the roots of many common plants produce sugar ; such are the turnip, and others of the cabbage genus ; the potato, the parsnep, and other plants which have tubers or large mucilaginous roots. None of these, however, has been cultivated on the large scale for sugar, though many of them have been subjected to experiments, which evince the possibility of deriving sugar from them in considerable quantity.

The Vine, *Vitis vinifera*, and other species of Grape, yield sugar ; but they are never cultivated for this purpose ; for, while they are inferior to other plants for the production of sugar, they are superior to any for the special purpose for which they are cultivated—the production of wine.

The Birch, *Betula alba*, when its stem is perforated, yields a large quantity of juice, from which sugar may be obtained by boiling ; and the inhabitants of countries where the birch abounds, supply themselves, in this manner, with a species of domestic sugar.

The Sugar-Maple, *Acer saccharinum*, is one of the innumerable marvels of the American forest, extending over a vast tract of country, from Lake St John, in Canada, to the upper parts of Pennsylvania. The juice is extracted in the early part of the year, while the ground is yet covered with snow, by boring holes

with an auger in the trunk. The juice, which continues to flow for five or six weeks, is conveyed to a trough at the foot of each tree, and collected every day, and poured into casks, from which it is drawn to fill the boilers, which are upon the spot. It is then evaporated by means of a brisk fire, until the liquid is reduced to a syrup, when it is left to cool, and it is then strained through woollen cloth, to separate the impurities. It is boiled a second time, until it is of a proper consistency to be poured into moulds. The sugar obtained in this manner is equally grateful to the taste as the brown sugar derived from the sugar-cane; and it is equally suited for culinary uses; and when it is refined, it equals the finest sugars consumed in Europe. The sugar of the maple supplies a large internal consumption in Canada and the Northern United States of America; but the plant has not been introduced for this purpose into the culture of Europe. Other species of *Acerineæ* yield sugar, but none of them in quantity equal to the sugar-maple.

But the plant which yields the largest supplies of this substance is the Sugar-cane. This plant is of the natural family Gramineæ, and it is of all the family that whose juices are the richest in saccharine matter.

The sugar-cane, however, cannot stand the cold of high latitudes. The zone of its cultivation extends to about 35°, or thence to 40°, on either side of the Equator; and it is only produced in the temperature of the colder countries of Europe by artificial means. It is partially cultivated in the islands of the Greek Archipelago, and its cultivation yet lingers in some of the provinces of Spain; but it is scarcely now regarded as one of the cultivated plants of Europe. Its produce, however, can be obtained, in unlimited quantity, from the intertropical regions of either hemisphere.

7. Plants Cultivated for their Narcotic, Bitter, and Tannin Principle.

1. Narcotic Principle.

Of the plants which afford the narcotic principle, the most important are the Tobacco and the Poppy.

1. The Tobacco, *Nicotiana*, is of the Nightshade tribe. It was before seen, that the wholesome and esteemed potato is of this formidable family of plants, possessing in its leaves and root, until expelled by heat, the same dangerous properties.

Of the tobacco there are many species. Those most generally cultivated are—

1. Nicotiana tabacum—Virginian Tobacco.
2. Nicotiana rustica—Common Green Tobacco.

Some of the many species of tobacco are natives of Asia, but the most important of them have been derived from the New World; and none of them appears to have been used for luxury or commerce till obtained from that continent.

The discovery of this plant is supposed to have been made by Fernando Cortes, in Yucatan, in the Gulf of Mexico, where he found it used universally, and held in a species of veneration, by the simple natives. He made himself acquainted with the uses and supposed virtues of the plant, and the manner of cultivating it, and sent plants to Spain, as part of the spoils and treasures of his new-found World.

But it was the Portuguese who were mainly instrumental in diffusing the tobacco plant over Europe and the East. The history of its introduction into different countries is very remarkable, but need not here be detailed. It is known, that the use of this plant, seemingly nauseous, has, in spite of all opposition, taken root as it were in every country, and become apparently essential to the comforts of the inhabitants.

The tobacco-plant grows in all the temperate zones to a high

latitude. It is cultivated extensively in Germany, France, and the Low Countries, in Sweden, Russia, and other parts of Europe. It required a long series of intemperate laws to arrest its progress in England, and its culture there is now directly prohibited, on account of the great revenue derived from the foreign commodity. It is not necessary here to canvass the policy of these laws. They can be justified only on the plea of necessity, which compels us to trust to the importation of foreign tobacco for a large part of the revenue of the country.

The tobacco-plant requires a rich light soil, and its cultivation is attended with a considerable labour of detail.

The seeds, which are very minute, are generally sown in a sheltered place, covered during the night to defend them from frosts, and, in the end of May or beginning of June, transplanted to the fields, and set in rows at a sufficient distance from one another. The culture they there undergo is hoeing, to keep them free from weeds, removing insects and injured leaves, and picking off the summits and buds, to prevent the flowering of the plant, and to direct the nourishment to the leaves.

When the leaves are ready, the stems are cut over, the plants hung up and dried, and then put up into heaps, and made to undergo a degree of fermentation. They are again hung up, the leaves being separated from the stems, and made to undergo a second fermentation, under a certain degree of pressure. The leaves are again dried, and tied together in bundles. They are then packed and compressed in casks, for sale or exportation, which completes the task of the grower.

The average produce differs very greatly under different conditions of climate and culture. Mr Brodigan, who cultivated the plant extensively in Ireland, states the produce in the county of Wexford at 1200 lb. per acre.

The whole details of the operation of culture will be found in various works. The most recent, with respect to its cultivation in this country, is by Mr Brodigan, whose treatise is very complete, and founded on experience. A full summary of the practice, as

pursued in different countries, is given in the *Nouveau Cours complet d'Agriculture*, by M. Bosc.

The tobacco-plant is found to grow in all the temperate regions, but that produced within the tropics possesses the finest flavour. The quantity produced and consumed of this plant is immense.

It may be asked, what it is which renders this seemingly unpalatable herb so grateful to the palate and the system in every climate, and in every form in which it can be used. Even in the most nauseous way in which it can be consumed, that of chewing, the use of it becomes a passion, and few that have used it in any form ever willingly abandon it.

It is evidently a soothing narcotic, of which the universal taste of mankind approves; and it is hard to believe that a taste so universal should be given for a substance that is in itself noxious. It may be abused, indeed, like many gifts of Nature; but all the presumption is, that, in moderate use, it is harmless as well as grateful.

2. The Poppy is of the genus *Papaver*, of which there are various species. That which is chiefly cultivated for its narcotic principle is

Papaver somniferum—The Opium Poppy.

The flowers of this species are sometimes white, when the seeds are also white; and sometimes the flowers are white and purple, when the seeds are of a darkish-blue colour. The first is the variety *album*, the latter the variety *nigrum*, of De Candolle. The darkish-coloured seeds are obtained from Germany, under the name of maw-seeds. This plant grows, in favourable situations, to the height of five or six feet. The petals of the flowers are of short duration, being succeeded by large round heads, somewhat flattened. It is from these heads or capsules that the opium is derived.

Being an annual plant, the poppy, when sown in spring, matures its seeds early in autumn. It is of easy culture, and can

be produced in the north of Europe, and the opium extracted from it.

In England, the seeds may be sown from the middle of March to the middle of April. The best method of cultivating the plants is in rows; and on the poppies attaining a few inches in height, they are hoed out to a distance from one another of six or eight inches.

When the heads are fully formed, but are yet green, the opium may be extracted. This process is simple, and may be taught to children in an hour.

Two or more vertical incisions are made in the capsule with a sharp knife or other instrument, about an inch in length, and not so deep as to penetrate through the capsule. As soon as the incisions are made, a milky juice will flow out, which, being glutinous, will adhere to the capsule. This may be collected by a small hair-brush, such as is used by painters, and squeezed into a little vessel, carried by the person who collects the juice. The incisions are repeated at intervals of a few days all round the capsule, and the same process of collecting the exuded juice is repeated.

The juice thus collected is opium. In a day or two it is of the consistence to be worked up into a mass. The narcotic matter of the plant may be also collected by boiling: but it is only the exuded juice that forms pure opium.

In the opium-countries of the East, the incisions are made at sunset, by several-pointed knives or lancets. In the following day, the juice is collected, scraped off with a small iron scoop, and deposited in earthen pots, when it is worked by the hand until it becomes consistent. It is then formed into globular cakes, and laid in little earthen basins, to be further dried. After the opium is extracted from the capsule, the plant is allowed to stand and ripen its seeds.

The seeds of the poppy, having nothing of the narcotic principle, are eaten by the people of the East as a nourishing and grateful food; and they yield, by expression, an oil which is regarded as inferior only to that of the olive.

It is the expense of labour, and the contingency to which the plant is subject from rains, that form the principal objection to the cultivation of the poppy in this country for its opium. The latter objection, indeed, is greater than the first. The processes of labour, though minute, are simple, and can be performed by children. The trials that have been made on the culture of the opium plant in this country, notwithstanding the partial success of some of them, lead to the conclusion, that opium may be better obtained from countries with a warmer and less humid climate than that of England.

2. Bitter Principle.

1. The most important of the plants cultivated with us for their bitter principle, is the Hop.

The Hop, *Humulus Lupulus*, has been cultivated in Europe during an unknown period, for its flowers, which are used for giving a bitter flavour to beer, as well as for preserving it. Its roots are perennial, and its stem ascends trees and other supports. It is a diœcious plant, that is, the male and female flowers are on different individuals. The male plants are technically called wild hops, and are rejected as of no value. The hop is a native of this country, and most parts of Europe. It flowers in England in June or July.

The hop is raised from slips taken from the stem, or from sets taken from the root. These are planted either in autumn or in spring; but the latter is the usual time. The plant is in its full bearing in its third year; and a plantation generally lasts from 12 to 15 years, when it must be renewed, the old plants being grubbed up, and fresh sets planted.

The slips or sets are obtained from the pruning of the plantations, or from the roots. Each slip should contain two joints or buds. The slips are sometimes planted in a garden for a season, before being set in a plantation.

The manner of forming the hop plantation is this :—The ground

is deeply ploughed, and well prepared. The places where the sets are to be planted are marked out, which may be done by a plough drawing parallel furrows, at the distance of eight feet from one another, and then by crossing these by similar furrows, at equal distances. The points where these furrows intersect, are the places where the sets are to be planted.

At each of these points of intersection, a hole is dug, and some manure put in it. A little hillock is made, and five, six, or seven sets dibbled in, forming a circle round the top of each hillock, at the distance of five or six inches from one another. They are set to incline inwards, and one generally is placed in the centre.

In the first year, the plants are tilled and hoed in the intervals, and the earth is drawn by the hoe around the roots of the plants, which is termed earthing. The principal earthing is in the first spring of the growth of the plant, but it is repeated annually afterwards in spring.

The process of tilling, hoeing, and earthing up, is an annual operation, and manure is applied generally once in three years. It is either laid on the hills of hops as they are termed, or in the rows. An esteemed manure for this plant is woollen rags.

The plants yield nothing during the first year. In the second year they yield their first crop of flowers. In preparation for this the poles are set. This operation is performed generally in the end of April, when the plants are 2 or 3 inches high.

The poles consist of straight shoots of ash, oak, willow, or other tree, from 6 to 9 inches in circumference at the base, and tapering to the size of a small cane. Two, but more generally three, or even more poles, are placed on each hill. They are fixed in the ground by making deep holes with an iron-crow, their tops inclining somewhat outwards.

The next operation consists in tying to the poles the shoots which it is wished to preserve. This is a work of skill, and one upon the right performance of which, part of the success of the crop depends. The shoots not to be preserved are cut away. The tying up of the shoots is by means of withered rushes, so loosely tied as to allow the free growth of the shoots. When the warm

weather arrives, the shoots grow with extraordinary rapidity, twining round the pole.

The season of picking the hop is usually the beginning of September. The proper period is known by the hop acquiring a strong scent. The manner of performing the work of picking is this :—

Frames of wood are raised in the most convenient part of the plantation. These frames consist of four boards nailed to four upright posts, the whole frame being about 8 feet long, 3 feet wide, and 3 feet high. Six, seven, or eight pickers, generally women or boys, are placed on the same frame, three or four being on each side. The plants being cut through at the roots, the poles are lifted up and laid on the frames with the hops upon them.

The pickers then carefully pick off the flowers of the hops, which they drop upon a large cloth which is hung upon the frame with tenter-hooks. When this cloth is full, the hops are emptied into a large sack and carried home.

The hops are then kiln-dried, which is done by placing them on a hair-cloth, 10 or 12 inches deep. The heat is gradually increased to the proper height, and continued steady for eight or ten hours. The hops are then taken from the kiln, and laid in a large room or loft until they become cool.

The next process is packing the hops into bags or pockets. In the floor of the room is a round hole, equal to the size of the mouth of the bag. The mouth of the bag is then fixed firmly to a strong hoop, which is made to rest on the edge of the hole. The bag is then let through the hole suspended by the hoop, and the packer goes into it. Another person puts the hops into the bag in small quantities at a time, and the packer tramples them firmly down. When the bag is full, it is drawn up, and the end sewed. The hops are now ready for sale.

In the mean time, the poles in the plantations have been stript of the stems attached to them, and piled in stacks, to await the following year.

The produce of the hop is more variable than that of any other crop. It is frequently nearly a failure. It is sometimes as low

as 1 to 2 cwt. to the acre, and sometimes as high as 20; the average produce may be stated at about 10 cwt. or less.

The stalks, like those of other plants of the natural family *Urticeæ*, yield fibres, which may be made into cloth. They are treated like the hemp; but the woody part is with more difficulty separated, and requires a longer maceration.

The hop is liable to diseases and the attacks of insects beyond any other of our cultivated plants. At the first stage of its growth, it is attacked by an insect of the flea kind, somewhat similar to that which attacks the young turnip. At a more advanced stage, it is attacked by numerous lice as they are called, the young of a little green fly, which frequently greatly injure or totally destroy the plant. Other insects also prey upon it, and plants of the mushroom family grow upon it, forming mildew or blight.

From this general account of the manner of cultivating the hop, it will be seen that the cultivation of it is attended with considerable difficulty, all the processes of tilling and dressing the plant, until its final preparation, requiring minute attention and much labour. It is also a very expensive species of cultivation, arising from the large outlay required for the poles. From this circumstance, from the great uncertainty of the returns, and from the whole preparation of the produce being subject to the superintendence of the excise, the culture of the hop in this country does not extend, and is not likely to do so.

The hop is used for preserving and giving a bitter taste to malt liquor, to which purpose it is exceedingly well suited. Many bitters, however, may be used in place of the hop, and these, on account of the enhanced price of the hop, are employed clandestinely in this country to a great extent. Some are injurious, as the *Cocculus indicus*, which has not only a bitter but a narcotic principle, and is in truth a poison; and others are innocent.

2. Common Broom, *Cytisus scoparius*. The young shoots of this plant yield a bitter; and the method adopted is to mix a portion of them with a quantity of hops.

3. Mugwort, *Artemisia vulgaris*. This plant, like some others

of the natural family to which it belongs, is tonic; and as it also yields a bitter, it may be used as a substitute for hops.

4. Ground-Ivy, *Glechoma hederacea.* This plant was formerly used for giving a flavour to ale. It belongs to the Mint tribe of plants, which are generally tonic and cordial.

5. Marsh-Trefoil, or Buckbean, *Menyanthes trifoliata,* is a common plant, perfectly wholesome, and as a bitter, is believed to be superior to the hop. It is the roots which are used for this purpose.

6. Quassia is also a bitter, used clandestinely in the brewing of beer. It is derived from the bark of a tree found in the woods of Surinam. It is a very intense bitter, and is used in medicine as well as in brewing.

7. But the most important of the plants yielding bitters are those of the natural family *Gentianæ.* The plants of the Gentian family seem intended by nature to supply this principle. They are herbaceous, and extend over almost every part of the World, from the highest mountains of Europe, to the arid sands of India and America. The principle of bitterness resides in their roots. They are all of them tonic and stomachic. They are the most generally extended febrifuges known, and are, consequently, valuable medicines for the most fatal class of disorders incident to the human race. *Gentiana lutea,* Yellow gentian, is a native of the Alps of Europe, and is chiefly employed in France and England: *Gentiana rubra* is the species principally used in Germany: and *Gentiana purpurea* in Norway and Sweden. Their properties are the same. The yellow gentian, when formerly employed in the Old English ales, was termed Bitterwort.

3. Tannin Principle.

The plants the most commonly employed for the purpose of yielding tannin are the Oak, the Willow, the Chestnut, and the Larch; and it is chiefly from the bark that the tannin principle is derived.

Of these forest-trees the oak is the most esteemed for its tannin, although it appears that certain species of willow are not inferior to it in the quantity and quality of the tannin which they produce.

The oak produces tannin from its galls, but it is chiefly produced from its bark, and this in the largest quantity when the buds begin to open in spring. It yields the smallest quantity in winter, after the autumnal descent of the sap. It is for this reason that the oak is too frequently cut down at a time which, though favourable for the production of tannin, is not so for the ultimate durability of the timber.

Sir Humphrey Davy made various experiments on the quantity of tannin yielded by the bark of different species of trees. He found that the greatest quantity was produced by the Leicester willow of large size. From 480 lb. of bark,

The Large-sized Willow yielded . . .	33 lb.
The Common Willow, ...	11
Coppice Oak, ...	32
Middle-sized Oak cut in spring, . . .	29
The Spanish Chestnut cut in autumn, . .	21
The Ash, ...	16
The Black Thorn, ...	16
The Larch, when cut in autumn, . . .	8

Of these trees, the larch, it will appear, yields the smallest quantity, weight for weight; but then the larch produces a considerable quantity of bark, for which reason it is common to strip the trees of their bark when felled. Other coniferous trees are rich in the tannin principle, as the Hemlock-spruce of America.

The Myrtle family of plants are some of them very productive of tannin. The loftiest timber trees of New Holland and Van Diemen's Land are of this family, and tannin in considerable quantity has been recently obtained from the Australian woods. From the same vast country Acacia has been imported on account of its tannin; for it is to be observed that several of this genus yield tannin in great quantity. In some species of Acacia of the

western parts of America, the extract yielded consists chiefly of tannin.

The Sumach is also of a tribe of plants which yield a considerable portion of tannin : one of the species, *Rhus Coriaria*, is used in Turkey for tanning the leather of that country ; another of the species, *Rhus Cotinus*, is said to be cultivated in the Apennines for the same purpose.

Tannin is found in the roots and leaves of many other trees and shrubs. Some common plants of the Rose family yield it largely, and indeed it is a very commonly diffused vegetable principle.

8. Plants Cultivated for their Resins.

The most important of the plants yielding resinous substances are the *Coniferæ* or Fir-tribe.

The trees which form the family of Coniferæ are of high importance, both on account of the timber which they produce, and their numerous secretions. It is with relation to the last of these productions that they are to be here adverted to. These secretions are termed *resins*, and they are of very great importance in the arts.

From the Wild Pine, *Pinus sylvestris*, frequently called the Scotch fir, is obtained common tar. The manufacture is carried on in those vast countries of pine which form so great a part of northern Europe.

The manufacture is simple. A conical hole, usually in the side of a bank, being made, roots and fillets of pine are let into the cavity, and the whole is covered with turf, which is beaten firmly down above the wood. The wood being kindled, a slow combustion takes place. A cast-iron pan at the bottom of the cavity receives the fluid, and has a spout which projects through the bank and carries the tar into barrels. As quickly as the barrels are filled, they are closed with bungs, when the material is ready for exportation. The manner of preparing tar has been derived

from the earliest ages. By the further application of heat, the tar is converted into pitch.

These two substances, tar and pitch, are of extensive use in the arts. The employment of them in the preservation of the ropes and cordage of shipping is everywhere known. The importation of tar into this country from the north of Europe and from America is very great. The tar of America, however, is not derived from the consumption of the wild pine, which does not exist in the New World, but from other species, and chiefly from the swamp pine, *Pinus australis.*

The Norway spruce, *Abies communis,* is applied to the same purposes as the wild pine.

Common turpentine is likewise an extensive production of certain coniferous trees. It is not obtained by heat, but by the natural exudation of the juices of the plants, through incisions of the trunk.

Turpentine is resolvable into two parts. The one is rosin, a substance extensively used in the arts. By distillation, oil is obtained, what remains being rosin. The oil of turpentine has frequently the name given to it of spirits of turpentine; but, though a very powerful substance, it has no resemblance to alcohol.

Turpentine is obtained from others of the pine family besides the wild pine; and, according to the species from which it is derived, the turpentine possesses peculiarities which fit it for different purposes in the arts.

Turpentine is extensively produced in the United States of America. A sort of cavity is formed at the root of the tree, capable of holding about a pint and a half of juice; and an incision being made in the bark, the turpentine flows into the cavity, which is emptied five or six times in the season.

Venetian turpentine is obtained from *Larix europæa,* the Common Larch. The turpentine of the larch is generally obtained from the Alps of the Tyrol; and the shipping-port being Venice, it thence derives the name of Venetian turpentine.

The Bourdeaux turpentine is derived from the Cluster pine, *Pinus pinaster*.

The Strasburg turpentine is derived from the Silver fir, *Abies picea*. This majestic tree is extremely prolific of resinous matter.

The Cyprus turpentine is obtained from *Pistacia Terebinthus*, the turpentine tree of the south of Europe. The islands of Cyprus and Chio are productive of this species of turpentine; which, however, is scarce, costly, and adulterated in commerce with the less valuable kinds.

The obtaining of the exuded juice in this manner does not, as in the case of tar, infer the destruction of the tree; but when turpentine is procured by incision, the tree is weakened, and hence, from the small extent of coniferous forests in this country, and from the time required for the collection of the exuded juice, it is found better to derive the turpentine employed in the arts from other countries.

Other resinous substances are, in like manner, obtained from various Coniferæ; as the Canadian balsam, from *Abies Balsamea;* the Carpathian balsam, from *Pinus Pinea;* the Hungarian balsam, from *Pinus Pumilio*, &c.

9. Plants Cultivated for their Fruits.

Of the plants cultivated for their fruits, the following classes may be enumerated:—

1. Vitis vinifera—The Vine.
2. Pyrus Malus—The Apple, and others of the Apple tribe; as the Pear, the Medlar, and the Quince.
3. Amygdalus persica—The Peach, and others of the Almond tribe; as the Plum, the Apricot, and the Cherry.
4. Fragaria vesca—The Strawberry, and other fruit-bearing plants of the Rose family; as the Raspberry, and others.
5. Ribes grossularia—The Gooseberry, and others of the Currant tribe.
6. Cucurbita Pepo—The Pumpkin, and others of the Gourd tribe.

7. Corylus Avellana—The Hazel, and others of the Oak tribe; as the Oak, the Chestnut, and the Beech:—Juglans regia, the Walnut; and other trees and shrubs bearing nuts and berries.

The first in the order of these fruits is the Vine, the true region of which, in Europe, is to the southward of the 50th degree of latitude. Within this zone, the vine is the most important of all the plants cultivated for their fruits, employing a large part of the industry of the inhabitants, and yielding the liquor which is in most general use. Beyond the natural limits of the vine, to the north, it is the plant of the garden, and is usually raised by artificial heat.

The next class of plants, the *Pomaceæ*, or Apple tribe, comprehends the most important of the fruit-bearing trees of northern Europe. They are hardy and of easy culture. They yield fruits employed in many ways as food, and their juice supplies a fermented liquor. They have been cultivated and improved with great care in England, which now numbers a vast variety of this class of fruits.

The next class comprehends many of our most esteemed fruits—the Apricot, the Peach, the Nectarine, the Plum, and the Cherry. Though highly valued for their juicy fruits, a dangerous principle, hydrocyanic or prussic acid, resides in their leaves and kernels, which renders them less safe as food than the fruits of the apple tribe.

The Strawberry, of different species, is a native of the Old World and the New, yielding an esteemed and wholesome fruit. Of this tribe are the Raspberry, and others, largely produced in the south of Europe.

The Gooseberry, and other plants of the Currant tribe, yield fruits which are esteemed in the colder, though not in the warmer parts of Europe. The plants of the Currant tribe are hardy, and of easy propagation.

The larger kinds of the Gourd tribe are cultivated in the fields. They yield a great produce where circumstances are favourable to their growth; but they are suited to the warmer, and not to the

colder parts of Europe. Of this tribe are the Melon and the Cucumber, which are plants entirely of the garden.

The last class of plants enumerated, consists of those of which the seeds are eaten. Of this class is the Hazel, which is sometimes cultivated on the larger scale; so likewise are the Chestnut and the Walnut; but the chestnut and the walnut belong to the warmer parts of Europe.

10. Plants Cultivated for Fermented and Distilled Liquors.

The juices and soluble matter of many plants are susceptible of the vinous fermentation. During this process, a principle is formed, alcohol, which may be obtained separately by distillation. The liquors, in their first state, are fermented liquors; such are wine, cider, beer. The substances obtained from these, by the process of distillation, are distilled liquors. Many plants are cultivated for yielding these substances. The most important of them are the followiug:—

1. The Vine.
2. The Apple, and other Pomaceæ.
3. The Peach, and other Amygdalaceæ.
4. The Strawberry, and other Rosaceæ.
5. The Gooseberry, and other Grossulaceæ.
6. The Cereal Grasses.
7. The Parsnep, the Carrot, the Beet, and other plants producing mucilaginous roots and tubers.

At the head of this class of plants stands the Vine, the fruit of which has, in every age, been employed for the production of fermented liquor. The vine may be cultivated within the tropics, but that is not the natural region of the cultivated vine, which, in the northern hemisphere, may be said to extend from about the 25th to near the 50th degree of latitude.

Although of vast importance to the agriculturists of the wine-growing countries of Europe, the fermented produce of the grape

can, in this and other countries similarly situated, be regarded only as the subject of commerce, since no supposable contingency can arise in the colder countries to render it expedient to attempt the cultivation of this plant for its wine.

It is otherwise with the next class of enumerated fruits, the *Pomaceæ*. These are hardy plants of easy culture, suited to the climate, and capable of producing, in unlimited quantity, a nutritive and grateful liquor. The wine of the apple is termed cider; that of the pear, perry. The preparation of cider is a simple process. The apples being gathered, which must be done when they are thoroughly ripe, are piled into a heap about a foot high. This heap may be defended from the rain, but the air should be allowed access to it. After the fruit has lain for a time to mellow, all decayed apples being in the mean time removed, it is carried to the bruising mill.

This, in most of the cider countries of Europe, is a very simple machine, consisting merely of a common millstone, placed vertically, and made to be moved round in a circular stone-trough by a shaft extending beyond the trough, to which a horse is attached. The vertical millstone should be made of any hard stone, but not of limestone, because the malic acid of the fruit acts upon the calcareous matter: neither should any lead be employed.

The vertical millstone may be 4 feet in diameter, and 10 or 12 inches thick; the groove in which it is to run in the trough may be 9 or 10 inches deep, of sufficient breadth at the bottom to allow the stone to move freely, and 6 or 8 inches wider at the top than at the bottom. The apples are strewed in the trough, and crushed by the stone as it revolves.

The pulpy mass being removed, is allowed to remain about twenty-four hours in a heap, after which it is carried to the cider press. This is usually formed on the principle of a common screw-press. Boards placed horizontally compress the pulpy matter, and the screw which presses them together is moved by levers. The pulp is placed usually in hair-bags, one above the other, between the horizontal boards. These are slightly compressed at first, and then more strongly, until the juice is fully

expressed. The juice is received in proper vessels, and after being pressed through a hair-sieve to retain the grosser parts, it is conveyed to a cask, where it is suffered to ferment.

The fermentative process proceeds, and when it is completed the liquor is withdrawn, or racked, as it is termed, the impurities being left behind. Should the vinous juice shew a disposition to ferment a second time, it must be again racked, and so on till the tendency to fermentation be removed. The cider now formed is put into the casks in which it is to remain. It is kept in these until it is fit for being put into bottles, when, if well made, it will be found to be a clear rich liquor, and will remain in these bottles, without loss of its properties, for twenty or thirty years. Cider, then, it appears, is a true wine without any addition to the fermented juice of the fruit.

The manufacture of perry is entirely the same as that of cider, the pear being substituted for the apple.

The preparation of these liquors is attended with no peculiar difficulty, and might be extended to every part of the country. It is not the finer garden apples that are required for the cider manufacture. They are rather of the less improved and harsher kinds, approaching somewhat to the wild apple. Nay, the wild apple itself, one of the most easily cultivated of trees, will yield good cider alone, but unexceptionable cider if mixed with a proportion of the cultivated apple. In truth, although most writers would have us to believe that there is something of much moment in the choice of a particular kind of apple, it is well established that the principal success of the cider production, in the different countries of the north of Europe, depends on the manner of performing the operation rather than upon the kind of fruit.

The Peach, the Plum, and others of the Almond tribe, also produce liquors, but these are generally distilled liquors. The brandy of the peach is extensively consumed in some parts of the United States of America.

The Strawberry, and other fruit-bearing *Rosaceæ*, and the Gooseberry, and other fruits of the Currant tribe, may also be converted by the vinous fermentation into wine.

The general character of these fruits is, that they are deficient in those saccharine properties which suit the grape and the apple tribe to the production of wine. They undergo the acetous in place of the vinous fermentation, and all of them, accordingly, require an addition of sugar to cause them to become wine. The addition of sugar produces readily the fermentation required; but it is common also to add a distilled liquor to give strength and flavour to them.

Those domestic wines are an article of household economy, and although they want the flavour of the wine of the grape, they are not unpalatable. Some of them undergo the vinous fermentation by the sole addition of saccharine matter, and do not require the addition of alcohol; aud these are true wines. Others again are not palatable, and will not keep without this addition; and these are not true wines, but a mixture of distilled and fermented liquors.

The next kinds of plants producing fermented liquors are the cereal grasses. In these, the soluble matter being obtained by infusion, is fermented, and forms beer. This class of liquors includes ale, porter, and the like, which are merely varieties of beer, their different qualities being produced by variations in the manner of performing the fermentative process, and by differences in the substances added to give strength and flavour to the liquor. The grains from which these liquors may be derived are chiefly wheat, rye, barley, oats, maize, millet, rice. In this country, the grain most commonly employed, and found best suited to the purpose, is barley.

In all cases of fermentation, the saccharine appears to precede the vinous fermentation. In the case of brewing from the seeds of the cereal grasses, it is usual, in order to promote the conversion of the fecula of the seeds into sugar, to cause them to germinate, and then suddenly to stop the germination. The seeds are then termed Malt, and can be preserved for use. This partial conversion of the matter of the seed into sugar is not, indeed, essential, for it appears that, without it, the saccharine fermentation will proceed under favourable circumstances.

The process of malting, then, is simply the production of a certain degree of germination, by which the starch or fecula of the seeds is partially converted into sugar. The grain is steeped for a time in cold water; the water is then allowed to drain off; and the grain is spread out in a thick heap, in which it gradually heats and germinates. When germination has taken place to a certain extent within the grain, the further germination is checked by exposing the grain on a kiln, heated to such a degree as to destroy the vitality of the seeds. The malt, after being bruised, is put into a mash-tun, as it is called, and hot water conveyed upon it. After this, the infusion is boiled, and, during the process of boiling, hops are added, and it is then cooled and fermented. Beer is therefore a wine, the soluble matter of the seed, instead of the pulpy matter of the fruit, being employed.

The last of the kinds of plants enumerated for yielding fermented and distilled liquors are the parsnep, the carrot, the beet, and other plants producing mucilaginous roots and tubers. The details of the operations differ from those in which the cereal grasses are employed, but the principle of the fermentative processes is the same.

By the vinous fermentation, it has been said, alcohol is produced, which may be obtained separately by the action of heat. This constitutes the art of distillation; and the substances which are capable of undergoing the vinous fermentation are capable of yielding alcohol by distillation.

Many plants not enumerated here are capable of producing fermented and distilled liquors. Thus various common grasses yield them in considerable quantity; and some berries, as those of the mountain-ash, ferment as easily as the juice of the grape.

11. Plants Cultivated for their Uses in Domestic Economy and the Arts.

The plants cultivated for their uses in domestic economy and the arts constitute a numerous class. They often yield good re-

turns of profit; but they are rarely cultivated in the field, and for the most part they fall more within the province of the gardener than the farmer. Those which may be here pointed out are,—

1. Dipsacus Fullonum—Clothiers' Teasel.
2. Sinapis nigra et alba—Black and White Mustard.
3. Coriandrum sativum—Coriander.
4. Carum Carui—Caraway.
5. Glycyrrhiza glabra—Smooth Liquorice.
6. Lavandula Spica—Common Lavender, and other Labiatæ.
7. Rosa rubiginosa, and other substitutes for Tea.
8. Cichorium Intybus, and other substitutes for Coffee.

Clothiers' teasel is cultivated in various districts of England for the raising of the nap on woollen cloths, which is done by the crooked awns of the head. For this purpose, the heads are fixed to the circumference of a broad wheel, which is turned round, while the cloth is pressed against them.

The clothiers' teasel is a plant growing several feet high, and terminated by the large head which is employed in the manufacturing process. The seeds are sown about the beginning of April, on soil well prepared. The general mode of culture is broadcast, though the row system would seem more suited to the plant, which requires cleaning and hoeing during its growth. In the common practice, the plants are hoed out to the distance of 12 inches from one another; and they are kept free of weeds by hoeing until the plants begin to shoot, which is in the summer of the second year. In proportion as the heads become ripe, they are cut off with a portion of the stem, and are then placed in a shed until they are dry. This crop may yield a good return, but it is necessarily of limited culture.

The Black and White mustard are plants cultivated for their oils. They are likewise applicable to other purposes, and in an especial degree to the making of the well-known condiment, mustard, which is in use in many countries.

Both these species are annual; they admit of easy culture, and ripen their seeds early in autumn. They may be sown in rows on a flat surface like corn, the distance between the rows being

12 inches, so as to allow a sufficient space for the hand-hoe. They require no other culture than weeding during their growth. When reaped, they are tied in bunches and left a few days to wither, and they are stacked, to remain till they are required for use.

It is the black species which is chiefly ground into flour, for mustard; although the white, which is less pungent, is frequently mixed with it. Both are mixed with the wild mustard, and wild radish; but the adulteration is not otherwise hurtful than as it is a fraud upon the consumer.

Several species of umbelliferous plants are cultivated chiefly for the aromatic flavour of their seeds. Of these are Coriander and Caraway.

Coriander is an annual plant, supposed to be a native of the south of Europe, but now naturalized in England. Its leaves and seed-vessels are strongly scented. Its seeds have an aromatic taste, and are used for confectionary and seasonings of different kinds. They are employed by distillers and rectifiers for flavouring spirits, and by druggists for various purposes. The plant is cultivated in Essex and other parts of England, and ripens its seeds in the same year in which it is sown. But it is common to sow it in September, when it is ready early in the following autumn. It is sown broadcast, although like many similar plants it may be cultivated in rows.

Caraway is of the same class of plants with respect to its uses; but it is a biennial plant, and is frequently sown with corn, the corn being reaped in the first year, and the caraway in the second. The seeds of the caraway are imported in large quantity from Holland. It is a native plant, and admits of easy culture.

The Smooth Liquorice is a leguminous plant, the roots of which yield a sweet and mucilaginous substance, which is employed in medicine and for other purposes. It is cultivated in some parts of England. It requires a light soil, deeply dug, and well prepared. The plants are cultivated from sets, in rows, three feet distant. They are tilled by the horse and hand hoe, and

after three summers' growth the roots are taken up for use. There is a great demand for the produce of the liquorice plant, which, amongst other purposes, is used largely in the brewing of porter. The extract from the root is usually imported from Spain in rolls or cakes.

Lavender is cultivated chiefly for the odour of its flowers, which is obtained by distillation. It yields an oil, which is employed in some of the arts. It is a perennial plant, and is easily cultivated. Various other species of the mint family, as sage, marjoram, thyme, and peppermint, are valued on account of their tonic or aromatic properties, and are cultivated on the small scale on that account.

Thea viridis, Common Tea, is now the subject of immense commerce. It is the leaves of this plant that are imported in such vast quantities, and the infusion of which forms something like a necessary of life in certain countries. China and Tartary supply tea in the largest quantity.

The leaves of the tea-plant seem to owe their grateful action upon the system partly to their stimulant properties. Many substitutes have been used, and are mixed largely with the tea consumed in this country, but none of them possesses the properties of the tea-plant of Asia.

The substitutes are the leaves of some of the plants of the rose family, as the *Rosa rubiginosa*, sweet-brier, and *Rubus arcticus*, common dwarf bramble ; of some of the currant tribe, *Ribes rubrum*, black currant ; of some of the almond tribe, as *Prunus spinosa*, the sloe ; of some of the mint family, as sage and balm ; and of some even of the heaths and ferns. In the United States, the leaves of the sweet-smelling golden rod, *Solidago odora*, have been found to be a grateful substitute for tea.

The Coffee-plant, *Caffea arabica*, yields a berry, whose decoction forms a well known beverage, the use of which has been derived by us from Asia. Europe is now supplied in immense quantity with the berry of the coffee-plant from the islands of the West Indies. This decoction is, like that of the tea-plant, grateful to the palate, and produces an exciting action upon the sys-

tem. Many substitutes have been used, but though generally nutritive and wholesome, none of them possesses the flavour and properties of the *Caffea arabica.*

The best of the substitutes for coffee are the seeds of certain leguminous plants, which may be prepared by roasting in the same manner as coffee. Two of these may be mentioned:

1. *Astragalus boeticus,* Boetian Milk-vetch, a plant which is cultivated in several parts of Europe, and used in the same manner as coffee.

2. *Lotus tetragonolobus,* Purple Winged-Pea. This plant is cultivated in Spain for the like purpose. It produces beautiful scarlet flowers, and is remarkable for its winged legumes.

But the plant which at present attracts the most attention as a substitute for Coffee is the Succory, *Cichorium Intybus,* which is also cultivated for forage. It is the root of the plant which is used. It is mixed largely with the coffee consumed in France. It is believed not greatly to injure the flavour of the coffee, and some even, from habit, prefer the mixture.

12. Plants Cultivated for their Wood.

The plants usually cultivated for their wood are divided into two great classes. 1*st,* The *Coniferæ* or Fir tribe, called also Resinous trees, and sometimes Soft-wood; and, 2*d,* the *Amentaceæ* and other tribes, frequently termed Hard-wood.

Trees of either class may be raised directly from seeds in the places which they are to occupy; but experience shews that it is generally more convenient to raise them in some place where they can be tended with care during the first stages of their growth, and, when they have acquired sufficient strength and size, to transplant them to the places where they are finally to grow.

In this country the care of the nursery has long become a distinct profession, and it is the natural effect of a division of labour that it should be so. Convenience will cause the greater number of planters to resort for their supplies of tree-plants to those

who devote their attention to the raising of them. But where planting is to be carried on upon an extended scale, the planter may form his own nursery, in which case he has the means of raising his trees with more economy, and on soils more similar to those on which they are to be ultimately cultivated.

A nursery of this kind should consist of soil of a medium degree of fertility, the extreme of too great richness, or too great infertility, being avoided. The soil, too, should be of the lighter kind rather than of the stiffer, because the lighter soils are better suited than the stiffer to favour the growth of the roots of young plants, and because they are adapted to a greater diversity of the kinds of the cultivated trees.

The situation of the nursery should be somewhat airy, without being too much exposed. To prepare the soil, it should be deeply trenched and thoroughly cleaned of the roots of weeds. If the land be not of itself fertile, it should receive a moderate manuring of lime and dung; for, although everything like forcing forward of the plants is to be avoided, as a great error in practice, care is to be taken that the land shall possess a sufficient degree of fertility to nourish and bring them forward.

The seeds of the trees to be cultivated are first sown in what are termed the seed-beds. These may be made about 4 feet wide, with little paths for passages between.

The ground of these beds being carefully digged and rendered smooth by the rake, and a little of the surface-soil being laid aside for the purpose of covering the seeds, these are to be scattered evenly on the surface, and a light wooden roller then passing over it, the earth, which had been laid aside, is to be spread carefully and equally over the seeds.

The seeds of resinous trees must be lightly covered, and so also must some of the hard-wood kinds. Those of the larch, the Scotch or wild pine, and the spruce, should be covered about a quarter of an inch, and sown in the month of April; whilst those of the oak, the ash, the chesnut, the sycamore, and others, may be more deeply covered, and sown at an earlier season. But some

of the hard-wood kinds require to be sown at a later period, on account of their being subject to injury from frost; and some may be sown in summer and autumn.

The young plants remain in the seed-beds for one or two years, during which periods they are termed *seedlings*. Some of the hardier resinous species, as the larch and the wild pine, may be transplanted at once from the seed-beds to the place which they are to occupy in the forest; whilst others, including several of the resinous, and all the hard-wood kinds, are first transplanted into lines in another part of the nursery, where they remain for one or more years, and then are transplanted to their place in the forest. The most of the resinous trees, when they are to be transplanted into the nursery lines, may be one year's seedlings; others of the resinous, and all the hard-wood kinds, should not generally be less than two year's seedlings before being transplanted to the lines. The transplantation from the seed-beds to the nursery-lines may take place in autumn, after the descent of the sap, or in spring, before vegetation has commenced. The operation may be performed by the spade, but is often performed by the dibble. The plants are set at such distances in the rows that the horizontal branches of the young trees shall not interfere with one another. In transplanting, no part of the root should be lopped or shortened by the knife, nor the roots doubled in putting them into the ground; and care should be taken in planting, where the dibble is used, that the root shall be fixed firmly without being compressed at the neck.

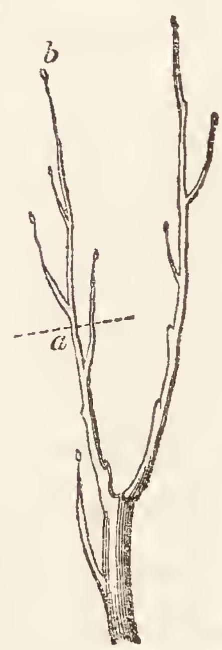
Certain kinds of tree plants, instead of being propagated by seeds, are propagated by cuttings, consisting of a portion of the shoot of the previous year's growth, 12 or 15 inches long. These cuttings are planted by thrusting one end a few inches into the ground. This is the manner in which willows and certain poplars are raised.

Certain kinds, again, are best propagated by layers. This practice consists in bending down the branches of a growing tree, fixing them in the ground by means of crooked pins of wood, and covering them partly with earth. In this state the covered part

quickly shoots forth roots, and the branch being then separated from the parent tree, becomes a distinct plant.

But in the case of the greater number of species, the practice is to sow the seeds in the seed-beds in the manner described. The hardier pines are often planted at once, as has been said, when seedlings; whilst others of the resinous species, and most of the hard-wood, are not planted in the forest until they have been one or more years in the nursery-lines, where they extend their roots, and acquire strength and size.

Fig. 188.



During the period in which the plants remain in these lines, they are to be kept free from weeds. They require no pruning at this early stage, further than to the extent of causing the leading or principal ascending shoot to preserve its ascendancy over the lateral and more horizontal ones, so that the plant shall not become what is termed forked, as in the figure. This may be simply effected by shortening one of the branches as at *a*, or by simply nipping off the terminal bud of the branch at *b*, by which means its lateral growth will be interrupted, and the main stem permitted to preserve its ascendancy.

The next operation to be performed is that of planting. For this purpose the ground is to be enclosed by an efficient fence, and freed, when necessary, of surface water, by open drains, traversing the space to be planted; and no further preparation is usually required than this fencing and carrying off of the surface water. It is not necessary to dig or manure the ground as for common crops. Nevertheless, when it is wished, from any cause, to hasten the growth of wood, and when expense is less regarded than accomplishing the purpose intended, the land may be trenched or even manured. This will hasten the growth of the trees, and render the failure of plants less frequent; but it is a method of forest culture which has narrow limits, and which is impracticable, on account of the expense, over the greater part of those lands which form the fitting subject of planting in this

country. Were it necessary to cultivate land in this manner before it could grow trees, a great part of the waste land of the country now covered with wood must have remained unplanted.

The plants of the nursery, then, are to be transplanted to their place in the forest, which may be done in the case of some species when they are seedlings, but which is to be done in the case of the greater number when they have remained one or more years in the nursery lines, and when they are said to be one year, two years, or three years transplanted, according to the number of summers which they have remained in the lines.

Two methods of planting may be practised. The one consists in making a slit in the ground with the spade, and putting in the plant: the other in digging a hole, in which the plant is placed, the earth being carefully shovelled over the roots.

The first of these methods may be practised with trees which are transplanted when seedlings, or even with pines and firs which shall have been a year in the nursery-lines. The other method is practised generally with plants which have been for some time in the nursery-lines, and whose roots accordingly have become extended. When the manner of planting is by slits, it may be performed thus:—

One person with a spade makes a deep slit in the ground, and then another slit crossing it. Having made the second slit, he bends down the spade until the slit becomes wide enough to admit the roots of the plant. An assistant, who attends with a bundle of plants, then taking one of them, slips it into the aperture formed by the spade. The spade being then withdrawn, the edges of the sods close upon the plant, the heel of the planter treading smartly upon the sod to bring the edges together. In this manner two persons may plant from 1000 to 1200 plants in a day.

Fig. 189.

Instead of the common spade, a small kind of spade, so light that it can be worked by the hand, may be used. When this instrument is employed, no assistant is required.

The person who plants carries a little bag of plants

before him : with the spade in his right hand he makes a slit in the ground, and with his left he places the plant in the slit, and then he fixes the plant by a stroke of the heel. Practice renders this method of planting easy. One person, by this simple process, will set from 3000 to 4000 plants in a day, in such a manner, we are informed by those who have planted on the largest scale of forest culture, that scarcely one plant will fail.

But this method of planting is suited only to seedling plants of not more than two years' growth ; for when they exceed that age, and come from the nursery-lines, the common spade must be employed, the strength of one hand not being sufficient to form a slit large enough to contain the root.

The other method of planting is performed by digging a hole by the spade. This is the method to be practised when the plants, by having grown in the nursery-lines, have acquired extended roots ; and the following is the method of proceeding :—

The holes are first digged in the number and at the distances required, the earth taken out of them being laid beside them. The trees are then planted, and two persons are employed at the work. The one places a plant in the centre of the hole, holding it upright by the top ; the other with the spade shovels the earth all round it. The earth being then trodden down by the foot, the tree is planted; and it is a point of good practice that the sod or richer soil shall be laid next the roots. The rules to be observed in this operation are, that the holes shall be of sufficient size ; that the plants shall be set upright, and be properly fixed in their position; and that no lopping away of the woody part of the root shall be permitted with the design of fitting it to the hole.

The distance to which the plants are to be set, is to be determined by the nature of the soil and situation. A common distance is from 3 to 4 feet. Trees ought in all cases to be planted at first much closer than they are intended to grow. The object of this is twofold :—1*st*, That there may be a provision against the failure of plants, and that those may be ultimately selected for

standing which are the most vigorous and best formed; and, 2*d*, That the plants may mutually shelter one another. For, although by this close planting the temperature of the air, as indicated by the thermometer, is not increased, the shelter afforded against the violence of the winds is found to contribute to the healthy, straight, and rapid growth of the trees.

After a time, and by degrees, the superfluous plants are to be cut down. It is not, therefore, necessary that all the supernumerary plants should be of the more valuable kinds of trees, which would unnecessarily enhance the expense. The cheapest and quickest growing trees are the best suited for sheltering the others, and none are so well adapted for the purpose, at least in cold countries, as the fir tribe; these being at once cheap, easily raised, and beyond every other kind suited to the sheltering of other trees, by their being evergreens. The firs thus intended for nurses, may be planted in slits, the hard-wood trees in holes.

The absolute necessity of sheltering by means of evergreens, doubtless only exists in a cold country, such as the more elevated parts of this island; and where the situation is low and the soil fertile, the sheltering by evergreens may be dispensed with. Still, however, even in the most favoured situations, the plants should be set close together, both for the purpose of providing for contingencies, and for promoting the tendency to upright growth in the trees.

The period of planting is between the fall of the leaf in autumn, and the time when the buds expand in spring, when the vegetation of the plant is inert, that is, from about the middle of October to the end of February. Between these two periods, all forest plants may be transplanted from the nursery to their ultimate destination, the precaution merely being taken that the weather shall be mild, and the ground not frozen, when the transplantation takes place.

The next operations to be performed are those of pruning and thinning.

The natural tendency of many trees is to rise with a conical stem shooting forth lateral branches from the base upwards.

Some species of trees, as most of the resinous and some of the willow and poplar kinds, do not generally tend to deviate from this form, the main trunk rising erect, surrounded from the summit to the base by smaller horizontal branches. But other trees, and these may be said to comprehend the greater part of the hard-wood, do not rise with the same regularity. Instead of one leading upright trunk, they send out many large boughs, which rival in size the principal trunk: such trees become forked near the base, and the principal trunk below is short, while the top is largely branched.

Now this is a form of the tree which, however conducive to beauty, is not so to utility. The main purpose of cultivating wood is for the timber, and the greater part of the useful timber of trees is contained in the trunk before it begins to shoot out into boughs. In the artificial cultivation of wood, therefore, it is important to produce as great a length of trunk, in proportion to the branched top, as a due attention to the natural habits of the tree will allow.

Further, it is important, for the obtaining of useful timber for the purposes of the carpenter, that the trunk shall be what is termed *clean* for as great a space upwards as possible. To understand the meaning of this term, when a branch shoots out from the side of the trunk of a tree, a part of the vegetable circulation is carried on through that branch ; and hence there is at this place an interruption of the continuity of the circulation. The fibres of the branch lie in a different direction from those of the main stem, and this, when carried to a certain extent, is injurious to the texture of the wood.

For these reasons, it is important that as great a part of the lower trunk as possible be freed from the lateral shoots.

Nature in part performs this process. As the tree rises in height, the lower branches decay and fall off, so that there are few trees in which, even if left to themselves there will not be a certain portion of the lower stems cleared of lateral branches. When trees are close together, this natural falling off of the lower branches takes place more quickly, and to a greater extent, than

when they are distant from one another. Thus, in natural forests the trees rise with very tall upright stems, and are gradually divested of all their branches below to a great height. It is from natural forests, accordingly, that our finest, tallest, and most valuable timber is derived.

But in the artificial culture of wood for its timber, we cannot entirely imitate the natural process, and allow the lateral branches to fall off by themselves. We must in this case admit the air to the trees, by keeping them at a distance from one another: and under these circumstances, the tree tends greatly to shoot out into branches, and thus to produce a smaller growth of upright stem, as well as to have a smaller extent cleared of branches at the base.

In the cultivation of wood, then, we must generally resort to artificial means to give the tree the form which we wish it to possess. We must first endeavour to promote the upright in place of the lateral extension, and then to have a sufficient portion cleared of lateral branches.

Further, the lateral branches should be taken off at as early a stage in the growth of the trees as is consistent with their health; for it is to be observed, that when a branch shoots from a tree, the twisting of the fibres begins at the point where the branch had originated, and not, as from a cursory inspection might be supposed, from the surface of the stem.

As in the practice of pruning, there are two distinct purposes to be aimed at; first, giving the vertical tendency to the tree, and second, obtaining as great a portion as possible of clean stems; so there are two periods in the growth of the tree at which these things are to be attended to. The first in order of time and importance, is giving the vertical tendency to the tree, and the second denuding it of its lower branches.

Until the tree has attained the height of 15 or 16 feet, the only end to be aimed at is to give it the upright tendency in question, and to prevent its becoming forked.

The pruning for this purpose consists in merely shortening such branches as may be rivalling the leading shoot, or stretch-

ing out laterally with a growth disproportioned to that of the others. Frequently the mere nipping off of the terminal bud will be sufficient to retard the growth of a branch; but in all cases it will be completely effected by cutting off the shoot as at *a*, Fig. 188, making it about half the length of the shoot above. This is the sole end in pruning during the first period of the growth of the tree; and it is to be observed, that if a tree be of itself tending to grow upright and without forking, no pruning, even of this simple kind, is required. For of all pruning, it is to be observed, that it is a violence done to the plant, and is to be avoided as much as possible. By cutting off branches and leaves, we cut off organs of nutrition. We do not prune that we may increase the quantity of wood, for the operation has a directly opposite tendency and effect; but we prune that we may give to the tree that form which is calculated to produce the greatest quantity of timber in the proper place.

The other branch of pruning, and the next in the order of time, consists in denuding the lower part of the trunk of branches, so that there may be obtained a sufficient extent of clean wood. Although, for the reasons given, it is important that the taking off of these branches be at as early a period as possible, yet this must be done always under the conditions necessary to preserve the health of the tree. The tree should, in the first place, have attained sufficient strength and age to bear the being deprived of its branches; and, in the next place, the process should be carried on so slowly as not to affect the healthy growth of the plant, and so gradually, that it may have vigour to cicatrize, or cover with bark, the wounds that have been made upon its surface. The period when we may safely commence this process of denudation is when the tree has attained the height of 15 or 16 feet.

Now, every tree adds to the length of its leading shoots and branches from buds which grow on the ends of the shoots. Every year a new shoot is made from each of these buds, of a length proportioned to the vigour of growth of the plant. The shoots thus formed in one year, produce each a bud, which, in like

manner, produces a shoot in the following year; and thus, while the tree is growing, there is a continued increase of the length of its leading shoots and branches. Further, when the annual shoot of any branch is produced, there is usually sent forth at the place where it originates one or more lateral shoots, so that there is a succession of branches or tiers of branches, from the base to the summit. Were these lateral branches not to fall off, we could, by means of them, ascertain the age of the tree; and in the case of many of the Coniferæ, we can frequently ascertain the number of years which they have lived, or that each individual branch has taken to grow, from the number of these annual shoots alone. A knowledge of this mode of growth will conduct us to a simple rule in practice for removing, without violence, the lower branches of the trunk.

Fig. 190.

When we commence this process of pruning off the branches of the stem, let us cut off the lowermost branch or tier of branches, that is, the branch or branches of one year's growth, and no more: in the second year let us cut off a second tier: in the third year a third tier; and so on. In this manner, while the tree in each year makes one shoot vertically, the lateral shoots of another year are cut off below. Thus, in the annexed figure, the tree having made 15 shoots, and having risen, we will suppose, to the height of 15 feet, we commence the process of pruning, by cutting off the lowermost branches or set of branches 1. The tree then makes a shoot from 15 to 16, so that while we have cut off the lateral shoots of

one year, another year's vertical shoot will be made. The next year we prune away the branch or branches 2; and again the tree makes a shoot from 16 to 17. In the third year we cut off the branch or branches 3, the tree making again a shoot upwards as before, to 18; and so we take off each year the lateral shoots of one year, and never more.

By this method we shall gradually denude the stem of its lateral branches from below upwards, while it is increasing in vertical growth. The extent of cleared trunk will thus gradually become larger in proportion to the uncleared portion or top. Thus, suppose that we begin to prune when the tree has made 15 years' shoots, then, when it has made 30 years' shoots, we shall have cleared off 15; that is, half the height of the tree.

Now, when we have cleared half the height of the tree, or a very little more, we should pause in our further operations, and mark its state of growth. If it continue to grow vigorously, we may resume our operation of close pruning, but at longer intervals than before, so as never, in any case, to have more cleared away than one-half, or at the utmost three-fifths, of the height of the tree, and never taking off more than one year's lateral growth of branches in a season.

Every tree, it is to be observed, must possess a sufficient top; that is, it must extend horizontally as well as vertically, so as to bear branches and leaves. The leaves are organs of nutrition of the plant, essential to the healthy exercise of the vegetable functions; and we must be careful to deprive it of no more of these organs than consists with our purpose in pruning. Now, by proceeding slowly in this gradual manner, never taking off more in any one year than the growth of one year's lateral branches, we shall not usually interfere with the healthy growth of the tree, but shall always leave it a sufficient power of expansion at top to afford it the means of nutrition and growth. Further, by never cutting off more at a time than the growth of one year, the tree will generally have vigour to cicatrize the wounds that have been made upon its trunk: whereas, were we to lop off many branches at a time, according to the practice too prevalent, the tree might

not have vigour to cover them with a fresh growth of bark, and thus the wounds might remain, to the lasting injury and frequent destruction of the tree.

In pruning in this manner, the branches are to be cut off quite close to the stem, so that the bark may quickly cover the wound; and although trees may be pruned in summer, the fittest period of pruning, as of all operations upon the living plant, is when vegetation is inert; that is, from the fall of the leaf to the period of the ascent of the sap in spring.

Thus, then, the operation of pruning may be said to be begun in the nursery, but at that time with an extreme degree of temperance, all the end of pruning at that early period being to prevent the plant from becoming forked. When the trees are transplanted to their ultimate situation, we may examine them in the third, or at latest the fourth year afterwards, and then, if more than one leading shoot is formed on any tree, we are to select the best, and shorten the others to about half the length of that which had been selected. And in like manner, when any branch or set of branches is seen to be extending laterally, with a growth disproportioned to that of the others, then, by merely shortening them, the tendency to the lateral extension will be sufficiently checked to allow the other branches to extend in an equal degree. And should we find that all the branches of a tree are tending to extend too much laterally, by merely shortening them in a slight degree, we shall give the ascendancy to one leading shoot, and so promote the upward tendency; and this is all the pruning required until the tree has attained, as has been said, the height of 15 or 16 feet, when the process of pruning the lower branches is to be begun, and carried on by the slow process described. But, even after we have begun the process of close pruning, we may still observe that the tree is ascending vertically, and if required, give this tendency from time to time by shortening any of the lateral branches.

It is not essential to the success of this method of pruning, that it be carried on every year. It will be sufficient to approach as near to the perfect practice as circumstances will allow, observ-

ing merely the general rule that *not more* than the growth of one year shall be taken off at a time, and that the process shall not be carried further than to the clearing off of three-fifths of the height of the tree.

The method of pruning by the shortening of the lateral branches, was brought into notice in England by the writings of Mr Billington, who had charge of a portion of the Royal forests ; and it was further developed and explained, with the addition of the gradual denudation of the lower branches, by Mr Cree in Scotland. To these deserving individuals is due the merit of having introduced, and to the latter that of having perfected, a system of pruning very greatly superior to that which had been before in use.

Pruning, as it is commonly practised, can scarcely be said to be founded on any principle. Branches are lopped off without limit or caution, and thus the growth of the tree is injured, and wounds are formed upon its surface which are never afterwards cicatrized. Often in the case of the youngest trees, we see the entire branches of successive years' growth lopped off in a season, and nothing left but a bush at the top. By this system of mutilation, millions of trees are sacrificed. A great proportion, indeed, of the whole cultivated wood of the country is annually destroyed, and it were better that the pruning-knife were never used at all than thus misapplied. The practice so common has probably been derived from that of the garden ; but it is to be observed, that, in the garden, the purpose in pruning is to repress the growth of wood and produce that of fruit ; and the principle, therefore, is in no degree applicable to the pruning required in the forest.

The principal instruments to be employed in pruning are a sharp knife, chisels with handles for reaching the higher branches, and sometimes a small saw for the larger branches. The hatchet is on no occasion to be used in pruning. The following figures represent the chisel and the saw. The saw here shewn is the Indian saw, which is made to act by being pulled towards the ope-

Fig. 191.

Fig. 192.

rator, in place of being pushed from him like the common saw of Europe. By being fixed to a long handle, this instrument is adapted to the cutting off of the higher branches.

When the proper direction has been given to the growth of the tree, and the lower branches have been pruned to the height to which it has been thought expedient to carry the operation, art has done all that it can do to render the tree useful. The natural growth of the tree must effect the rest. The trunk will increase in diameter by the addition of concentric layers of wood, yearly formed between the bark and the stem. The longer a tree stands while in a growing state, the thicker will its trunk become, and the more valuable. It makes wood rapidly, to use a familiar expression, when the trunk has become of good size; and it is an error, therefore, to fell wood which is intended for timber too soon.

In the pruning of forest trees, one of the most frequent errors committed is to delay the process till too late. By this delay the form of the tree is often rendered such that it cannot be restored; and the lopping off of large branches in the manner often practised, in order to give the tree a better shape, is for the most part attended with the evil of disfiguring it more, and enfeebling its growth. We constantly see these mistaken attempts to repair past neglect, by the lopping off of large limbs, the places of which the tree now wants vigour to heal. Vast numbers of trees are destroyed by this system of mutilation, when all further object in pruning is at an end. Sometimes a large branch may be lopped off when a tree is top-heavy, or when a branch is likely to be split, or for some other good reason. But it is an error, which must end in disappointment, to begin this system of lopping a full-

grown tree, with the design of compelling it to resume its process of increase when it has naturally ceased.

When a tree has been neglected, but is not yet so far advanced but that we may hope to restore it, we have merely to apply the principle of pruning explained to the case of the particular tree. We have to shorten the lateral branches which are forming forks, so as gradually to produce the upright tendency of the leading stem required. The rule is to proceed with the greatest temperance, taking care never to do too much in one season, lest, by depriving the tree of its branches, we enfeeble its vigour and impede its growth.

The process of pruning has been described, but there is another part of forest-culture coincident with pruning, and of equal necessity. This is the thinning out of the superfluous trees, so as to admit the air, and give room to the trees that are to remain. The trees, we have seen, have been planted greatly more closely than they are intended to grow, and many of them were designed merely to shelter the others during the early stages of their growth.

Whenever the horizontal branches of trees begin to cross one another, the process of thinning should commence. This is to be done by cutting out such a quantity of the inferior trees, as shall allow a sufficient space between the remainder. The first thinnings of this kind will be of little value, and will not repay the expense of clearing them out. Yet it is necessary that they be cleared away, in order to allow space and air for those which are left.

From the period when this first thinning is made, the plantation should be gone over every two or three years, and the same process repeated, observing the simple rule that the boughs shall never be so close as to interlace. If the plantation consists of a mixture of hard-wood and resinous trees, the whole of the latter should have been cleared away by the time the wood is 14 years old or less, and the great mass of it long before. After this the hard-wood trees should be kept at the distance from one another of about half their height.

When a plantation consists entirely of resinous trees, they may be kept much closer together than in the case of hard-wood. Still it is important, in the case of the resinous trees, that the thinning be continued frequently, so that they shall not crowd upon one another. It is by neglect of this point that many thousand acres of cultivated wood become comparatively useless.

The most frequent mistake committed in the management of mixed plantations of resinous trees and hard-wood, is the allowing of the former to remain until they have choked and enfeebled the hard-wood. This is done with the design of allowing the resinous trees to remain so long that they may be of some value when cut down. This, however, is an error of practice, by which the value of the hard-wood is lessened, while the full value of the softer wood is not obtained.

The habits of the resinous trees and the hard-wood kinds are very different ; and when the end proposed is merely the raising of wood for future profit, the two kinds will be best cultivated separately. It is not an exception to this principle that firs and pines are planted along with hard-wood. They are planted for the purpose of shelter, and they should be removed as soon as they have served this purpose. It is by allowing them to remain too long, with the design of combining the profit of the two classes of trees, that the hard-wood in many mixed plantations is stifled and rendered useless.

Again, when the end proposed is the profit to be derived from resinous trees, they are best planted without any mixture of hard-wood. In this manner, a greater quantity, and of better quality, can be raised from a given space. They can be suffered to arrive at maturity, and then cut down when really of value ; whereas, if mixed with hard-wood, they would need to be removed long before they had become of use.

And not only when ultimate profit is looked to should the two classes of trees be cultivated separately, but in many cases, in the planting of hard-wood, the same kinds of them should be planted together. Thus a forest of oaks will be more valuable if unmixed with other trees. Besides, the oak possesses the

property of springing again from old stocks when cut down. In this manner, after being felled, the plantation is formed into coppice, and made to yield periodical returns at intervals of 25 or 30 years. In like manner, willows and poplars are best planted in groups by themselves. In this case, a greater number of them can generally be raised upon a given space in the situations suited to them; and some of the species of willows, by being cut regularly, may be formed into osier plantations, and yield successive crops.

These are considerations to be regarded when the end is the profit to be derived from the wood; but when the taste is to be likewise gratified, then the mixed plantation, with its varying tints and diversified forms of trees, may claim a preference over that which, on a mere calculation of profit, would be chosen.

Different species of trees, whether planted together in groups or intermingled with others, have each peculiarities with respect to the manner of their growth, the soils and situations to which they are suited, and, in some cases, the method of management. With these differences the forest planter should be rendered familiar. But the description of species and the manner of cultivating them, forms itself an extensive branch of rural economy, which would exceed the limits which could be assigned to it in an elementary work. The end proposed here has been to explain the general practice of planting, and the management of forest-trees, without entering into the lesser details, or into a description of the different species which are, or which may form, the subjects of cultivation.

The following may be enumerated as forest-trees adapted to cultivation in this country:—

1. Pinus sylvestris—Wild Pine.
2. Pinus Laricio—Corsican Pine.
3. Pinus Cembra—Siberian Stone Pine.
4. Abies communis—Norway Spruce.
5. Abies Picea—Silver Fir.
6. Abies nigra—Black Spruce.
7. Abies alba—White Spruce.
8. Larix europæa—Common Larch.
9. Larix pendula—American Black Larch.

These are all resinous trees, sufficiently hardy for forest culture in this country.

Of the hard-wood kinds there may be enumerated :—

1. Quercus Robur—Common Oak.
2. Quercus sessiliflora—Sessile-fruited Oak.
3. Quercus Cerris—Turkey Oak.
4. Quercus alba—White Oak.
5. Juglans regia—Walnut.
6. Castanea vesca—Sweet Chestnut.
7. Æsculus Hippocastanum—Horse Chestnut.
8. Fagus sylvatica—Common Beech.
9. Carpinus Betulus—Hornbeam.
10. Betula alba—Common Birch.
11. Betula pendula—Weeping Birch.
12. Betula lenta—Black Birch.
13. Betula papyracea—Canoe Birch.
14. Alnus glutinosa—Common Alder.
15. Salix alba—White Willow.
16. Salix russelliana—Bedford Willow.
17. Salix triandra—Long-leaved Triandrous Willow (for osiers).
18. Populus alba—Great White Poplar.
19. Populus dilatata—Lombardy Poplar.
20. Populus tremula—Aspen.
21. Ulmus campestris—Narrow-leaved English Elm.
22. Ulmus suberosa—Common Cork-barked Elm.
23. Ulmus montana—Wych Elm.
24. Fraxinus excelsior—Common Ash
25. Fraxinus americana—White Ash.
26. Fraxinus quadrangulata—Blue Ash.
27. Acer Pseudo-platanus—Sycamore.
28. Acer platanoides—Norway Maple.
29. Tilia europæa—European Lime-tree.
30. Tilia rubra—Red-twigged Lime-tree.

Of the class of smaller trees cultivated for underwood, the following may be mentioned :—

1. Corylus Avellana—Common Hazel.
2. Prunus Aucuparia—Mountain Ash.
3. Cratægus Oxyacantha—Hawthorn.
4. Cytisus alpinus—Laburnum.
5. Ilex Aquifolium—Common Holly.

6. Prunus Laurocerasus—Common Laurel.
7. Prunus lusitanica—Portugal Laurel.

When it is wished to form a mixed plantation of these and other species, they are to be planted of the kinds and in the proportions which are best suited to the soil and situation.*

The profit to be derived from planting will appear to many to be contingent and distant, and yet to expend capital on planting, may be to lay out money to increase at a high rate of interest.

* The following is an example of a mixed plantation, in which the larch, the spruce, and the wild pine, are designed to serve the purposes of nurses:

300 Oaks,	20/	Per 1000.	L.0	6	0
100 Wych Elms,	12/6	...	0	1	3
150 Ashes,	12/	...	0	1	9½
25 Sweet Chestnuts,	25/	...	0	0	7½
50 Beeches,	15/	...	0	0	9
50 Sycamores,	12/6	...	0	0	7½
50 Weeping Birches,	25/	...	0	1	3
All these plants should be from 1½ to 2 feet high when planted; but not exceeding 2 feet.					
25 Bedford Willows, from cuttings,	10/	...	0	0	3
25 White Poplars, from 3 to 4 feet high,	50/	...	0	1	3
50 Hollies, from 9 to 12 inches,	20/	...	0	1	0
50 Laburnums, from 2 to 3 feet,	20/	...	0	1	0
50 Mountain Ashes, from 2 to 3 feet,	20/	...	0	1	0
50 Hazels, 1½ foot,	17/6	...	0	0	10½
50 Silver Firs, 1 foot high,	25/	...	0	1	3
500 Larches, 1 foot high,	2/6	...	0	1	3
500 Norway Spruces, from 9 inches to 1 foot high,	3/	...	0	1	6
1531 Wild Pines, about 9 inches high,	2/	...	0	3	0½
3556, being 3½ feet apart,			L.1	4	8½
Expense of planting,—the willows, larches, spruces, and pines being put into slits, and the others in holes,			0	16	6
			L.2	1	2½

To this is to be added the expense of enclosing, which increases in a great ratio as the space to be enclosed is lessened. Thus, to enclose the following quantities of land, in the form of a square, with a stone wall, at 1s. 2d. per yard in length, will be as under:—

Acres.	Total Expense.	Expense per Acre.
50	L.114 16 0	L.2 5 11
10	51 6 8	5 2 8
1	16 4 7	16 4 7

When the space to be enclosed, therefore, is 10 acres, the expense by the acre is

Planting, therefore, may be to the landed proprietor a mode of setting aside a fund for a future purpose, and an estate may be preserved to a family by capital wisely expended on this improvement.

But the profit is usually derived from planting land that is otherwise of comparatively little value. It is not the lands that will yield a good profit by cultivation that will yield a good profit by planting, but those that are otherwise little productive. Superior soils will produce more valuable wood; but, taking into account the loss of rent for the long period of the age of a tree, it is the class of soils low in the scale of fertility and value that usually yield the largest return for planting.

In the practice of forest culture we should take care that the work of planting be executed well. When we employ the common labourers of the country, the digging of the holes for the trees may be done by contract; but the putting in of the plants should be by days' labour, in order that the persons employed

about $2\frac{1}{4}$ times more than when it is 50 acres; and when the quantity is only 1 acre, it is about 7 times more. Hence the error of planting in patches. This may be done for shelter or embellishment; but when profit from the timber is looked for, the difference between planting on the large and small scale may make the difference between profit and loss in the plantation.

The expense of planting as above, per acre, is . .	L.2	1	$2\frac{1}{2}$
of enclosing, when the extent is 50 acres, .	2	5	11
	L.4	7	$1\frac{1}{2}$

Now, the following calculation will shew the amount of the cost of planting, enclosing, and the rent of the land, up to the period when the outlay may be expected to be repaid; that is, when the wood has arrived at maturity, and is fit for being cut down:—Let it be supposed that wood requires sixty years to reach the age of good timber, and that the land is worth 5s. per acre yearly in its original state, then, rating money at 5 per cent. compound interest, the amount of

5s. yearly for sixty years is	L.88	7	11
The expense of planting and enclosing, L.4 : 7 : $1\frac{1}{2}$ for the same period, principal and interest, is	81	7	5
	L.169.	15	4

So that, if the wood shall be worth L.169 : 15 : 4 at the end of sixty years, the original capital and the loss of rent will have been repaid. But L.169 : 15 : 4 per acre would be a very low price of wood of sixty years' standing. Five or six times the amount, independent of the value of thinnings, might be expected to be derived; and, therefore, on the conditions supposed, the capital would be profitably laid out in planting.

may have no interest in executing the work in an imperfect manner.

In choosing plants in the nursery, care must be taken to select those that are of a proper size. It is an error to select plants because they are large. Such plants may perish or become enfeebled when transplanted from the nursery to the forest. Yet this is the kind of plants that inexperienced planters are apt to prefer. Care, too, should be taken that the plants selected be of healthy growth, and free from forks.

When land has been planted, the ground should be examined regularly for several years afterwards, and the plants that may have died replaced. The ground should be kept free of stagnant water, and carefully defended from trespass during the early stage of the growth of the trees.

13. Plants Cultivated or used for Forage or Herbage.

Plants cultivated for forage are those which are mown, and used, either in a green or dried state, as the food of animals. Plants cultivated for herbage are consumed upon the ground where they are produced. Certain kinds of plants are better suited for forage than herbage. But many are adapted to either purpose, and therefore no distinct line can be drawn between the two classes.

The plants usually cultivated or employed for forage or herbage, are—

1. The Tare and other species of Vetch.
2. Lucerne, and other species of Medick.
3. Sainfoin.
4. Wild Succory, and other plants producing leaves suited for forage.
5. Clovers, Vetchlings, Melilots, &c.
6. Heaths, Sedges, and Rushes.
7. Rye-grass and other grasses.
8. Burnet, and other plants producing herbage.

1. The Tare.

The Tare, *Vicia sativa*, is one of the most esteemed of the leguminous forage-plants of this country. It is an annual plant, indigenous, and hardy. There are several varieties of it, one of which is distinguished by producing yellow seeds.

The tare, by being sown in autumn or in spring, acquires habits so different, that many have supposed the spring and winter tares, as they are called, to be different species. They are, however, the same species, and do not even constitute botanical varieties; but, from the different habits of ripening which they acquire, they should be always sown at the periods to which they are respectively suited; that is, the winter-tares should be sown in autumn, and the spring-tares in spring; for experiments have shewn, that the spring-tares sown in autumn will frequently perish in the first frosts, while the winter-tares will continue uninjured. This requires the more attention, as the seeds of the two kinds are so similar that no means of discriminating them exist.

When tares are cultivated for green food at a late season, they are to be sown in spring; and in order to procure a succession of cuttings during the months of summer and autumn, portions of the ground should be sown at intervals from the middle of March till the end of May.

When tares are to be sown in autumn, for early feeding in the ensuing season, the land frequently receives only one ploughing, after which the seeds are sown in the usual manner, and harrowed. A little farther tillage, however, would be beneficial, so as thoroughly to prepare the ground.

When tares are sown in spring, the land should receive a ploughing before winter, as in the case of pease and beans. It should be cross-ploughed again in spring, and well harrowed, and receive a second ploughing if possible: for it is always well to prepare the surface carefully for the seeds of this plant. After they are sown, the land should be rolled, to facilitate the subsequent

action of the scythe. If manure had been required for the crop, it should have been applied in the previous autumn.

Tares should always be sown on land which is in good condition and clean. It is a great error to sow tares on land which is not in this state. The tares are considered in many places as a kind of bye-crop; hence they are left to struggle with weeds, and many important advantages attending their cultivation are lost. The management of the tare in England is much superior to that pursued in Scotland.

The quantity of seeds sown may be from 3 to 4 bushels to the acre. When the crop is sown for its seeds alone a smaller quantity will suffice, as 2½ bushels to the acre.

It is common to mix a portion of some of the cereal grasses with the tare, the effect of which is to increase the quantity of fodder; the stems of the grasses rising above the foliage of the tares, and both growing without interrupting one another. For winter-tares rye is best suited, for spring-tares, oats or barley.

Tares, when used as green forage, are cut after the pods are formed, but long before the seeds become ripe. Tares, therefore, being in the class of crops not allowed to mature their seeds, are not very exhausting to the soil. On the contrary, with relation to the farm, they are to be considered as restorative crops, from the quantity of manure which the consumption of them affords. They are exceedingly nutritious, and supply a larger quantity of food for a limited period than most other forage crops.

The usual mode of sowing tares is broadcast, though they are better sown in rows, like the pea and the bean. This, indeed, is by no means so essential to the success of the crop as in the case of the bean and pea, for the produce of the tare is chiefly the stem and leaves, and the pods and seeds are of little comparative importance; the admission of air, therefore, for the swelling of the pods and seeds is not necessary. The plants, too, cover the intervals of the rows quickly, and so do not admit of much time and opportunity for tillage during their growth.

Tares are chiefly cultivated for green forage; but they may be also cultivated partially for their seeds. In this case, the mode

of culture is the same as that of the pea. The land should not be too rich, so as to cause them to run to straw instead of producing pods; and it is a good practice to mix up a small quantity of beans with them, to support and keep them from trailing on the ground. The beans, from their difference of size, are easily separated by riddles from the tares. In the practice of the farm it is common to cultivate tares for green forage, and merely to reserve that part of the crop for seeds which is not used in this manner. They are then reaped, stacked, and dressed, like pease.

When the tare is cut very early, it may rise again and produce a second crop; and even a third cutting is sometimes obtained. In the northern parts of the island, the farmers scarcely ever attempt to produce more than one crop in the season.

Tares are sometimes consumed by penning sheep upon them; but the better practice is to feed the sheep from racks. When the larger animals are fed on this food, it should always be supplied to them from racks in houses or yards.

All the animals of the farm are fond of this legume, and all thrive upon it in an eminent degree. Hogs may be fattened entirely upon it. It is suited to milch-cows, causing them to give more butter than any other species of food, and it is employed extensively in the feeding of horses. All the English agriculturists are impressed with a high opinion of the value of tares. They are not only casually employed, as in Scotland, to fill up the intervals between the cuttings of clovers, but they are often the principal source of feeding from the month of May to November.

There are several species of Vicia, with broad leaves resembling those of beans, cultivated in Germany for the same purposes as the tare:

1. Vicia narbonensis—Narbonne Vetch.
2. Vicia platycarpos—Broad-podded Vetch.
3. Vicia serratifolia—Saw-leaved Vetch.

But none of these species is equal in productiveness to the common tare.

Another of the genus *Vicia* is *Vicia pseudo-cracca*, Annual Tufted Vetch. This species is of a very luxuriant growth, but flowers at a late season. It is, as yet, untried in the agriculture of this country. It might, perhaps, supply a desideratum, namely, the affording of a large quantity of green forage after the pastures have begun to decay in autumn, and before the turnips and similar plants are ready for use.

Vicia biennis, Biennial Vetch, is a native of Siberia. This species is of luxuriant growth, and comes early in spring. It was cultivated by Miller so long ago as 1759, and recommended by him as a plant of great promise ; but no experiments upon it on the large scale are recorded. Its stems have a certain degree of hardness, and its leaves a somewhat insipid taste.

Vicia sylvatica, Wood-Vetch, is perennial. It grows in woods with a stem from 3 to 5 feet high, climbing by its tendrils, and bearing beautiful little flowers streaked with bluish veins. The wood-vetch, as its name denotes, is truly the inhabitant of woods, and, when removed to exposed situations, its size and productiveness diminish. For this reason, perhaps, it is not adapted to cultivation.

Vicia Cracca, Tufted Vetch, grows in hedges and bushy places, climbing also by tendrils, and bearing numerous purple flowers. It is, like the last, perennial, but is more productive when removed from its natural habitat. It is, however, late in growing, and appears to be much inferior in usefulness to the clovers. It grows on soils of low fertility.

Vicia sepium, Bush Vetch, is a plant growing also in hedges and bushy places. It is perennial, flowers early, and yields a good weight of produce. Although its natural habitat is bushy and shady places, it grows in cultivated fields, and has a somewhat wide range of soils. From these characters, and the trials that have been made, there is reason to infer that the bush-vetch would be a beneficial addition to the cultivated herbage plants of this country. There is great difficulty in procuring its seeds in

the wild state, from its dispersing them as soon as ripe; a character, however, which would probably be changed by cultivation, as happens in the case of other wild plants.

Of the important genus *Vicia*, about 100 species have been enumerated by botanists, and many of them seem to be highly deserving of experiment for their economical uses.

2. Lucerne.

This plant, *Medicago sativa*, has been cultivated in Spain, Italy, and the south of France, and on all the northern shores of the Mediterranean, time out of mind. It is cultivated in the countries of the East. It was familiar to the Greeks and Romans, from whom we derive minute accounts of its nature, properties, and culture.

Lucerne has a perennial root, and grows, when cultivated, from a foot and a half to two feet high and more. It is covered with leaves, downy below, and slightly so on the upper surface: it bears a flower of a fine purplish-violet: it flowers in June and July.

The cultivation of lucerne has been long stationary or retrograde in the British Islands. In Guernsey and the islands of the Channel it maintains its reputation, and justly so, the climate and soil of these islands being suited to the plant. For the same reason, it is esteemed and partially cultivated in Kent, and some of the southern counties of England.

The soil adapted to lucerne is deep and of the lighter class, with a free or kindly subsoil. When these circumstances do not exist, it is better not to attempt the cultivation of lucerne in this country.

Two methods of raising this plant have been recommended and practised. The one is sowing it broadcast in spring, sometimes along with a corn-crop, in the same manner in which we sow clovers, and sometimes without a crop; and the latter is the better practice, lucerne not being suited to grow freely under the

shade of other plants. The other method of cultivating lucerne is in rows. Lucerne, like other cultivated forage plants, gradually gives place to the grasses and hardier indigenous plants. When cultivated in rows, and carefully hoed, these native plants can be kept down, and the lucerne preserved for a long period in the ground. But, when sown broadcast, this cannot be done in the same degree, and the lucerne then does not generally endure beyond nine or ten years. This is the main advantage which the row system possesses over the broadcast, in the cultivation of this plant.

The best period of sowing lucerne is at or before the middle of April. When sown broadcast, the quantity of seeds to the acre may be 16 or 18 lb.; and when sown in rows, 10 lb.

The soil should be well prepared by deep ploughing, and a previous summer-fallow, or fallow-crop, such as potatoes, turnips, or carrots. But when it is wished merely to possess a few acres of lucerne for the convenience of soiling, it is better to have the soil deeply trenched and prepared like a garden-bed, and at the same time well manured with dung and lime.

When drilled, the rows need not be more than 18 or 20 inches apart, which will give room for tilling the intervals by the horse and hand hoe.

After the seeds are sown, care must be taken to keep down, by means of the hoe, all weeds that spring up amongst the plants and in the rows.

In the month of August of the first year when in flower, the crop may be mown, and, after this first cutting, the shoots may be kept down by a slight pasturing with sheep, but not while the soil is wet, nor should it be continued to a late period.

Early in the following spring the ground is to be horse or hand hoed, so that all weeds may be kept down, and the earth stirred about the roots of the plants. In the month of May the crop will be ready for the first cutting.

After being cut, it is to be horse-hoed in the intervals of the rows. It will now grow very rapidly; and, when ready for cut-

ting, is to be cut again, and, after each cutting, hand-hoed. In this manner it may be mown four or five times in the season.

It does not, however, arrive at its full growth till its third year, after which it will yield a large return in rich and early foliage. But it requires to be manured at intervals, as every third year. The manure may be farm-yard dung, spread upon the surface after the last cutting in autumn, or early in spring.

When the system of broadcast is adopted, the difference in the method of tillage is, that, in place of the horse and hand hoe, the common harrow is used, which, passing over the surface, stirs the soil about the roots of the plant, and drags up and destroys weeds; the lucerne itself, having a strong root striking downwards, is not torn up by this rough treatment, but, on the contrary, is benefited by the stirring of the soil round its roots and stems.

This plant is eminently wholesome and nutritive. It is well suited for milch cows, causing them to yield good and abundant milk. It is perfectly adapted to the feeding of horses, and this, indeed, is one of the most common purposes to which it is applied. It may be used with the like advantage for the soiling of any kind of stock. It is valuable for the early feeding which it supplies, being in this respect considerably before the clovers. When we possess a portion of lucerne, therefore, we can begin to soil at an earlier period than could otherwise be done.

Portions of lucerne cultivated on the small scale, and with care, have been found to maintain a great number of animals; and hence its advocates have formed an erroneous estimate of its fitness for extended cultivation. But although lucerne is very productive in itself, it is not a species of crop which is suited to general culture in this country. It takes three years to arrive at maturity, and it is very liable to fail from the attacks of insects in the first year of its growth. It requires manure to be applied to the surface to keep it productive, and this is a wasteful mode of applying the manures of the farm. It requires also a deep rich soil, which is not always to be found. The limit, then, to

which it seems beneficial to confine the cultivation of lucerne, is to that of a small portion, for the purpose of supplying the place of the common forage plants in early spring, and of using it in addition to these during summer. With this design a few acres may often be very conveniently applied to its production; but beyond this its cultivation can rarely be recommended in this country. Where the alternate system of husbandry is pursued, a better method of raising green food for stock is practised than applying any part of the farm constantly to that purpose.

The most productive of the genus *Medicago*, is the species which has been described; but there are others which are cultivated. Two of these may be mentioned—

1. *Medicago falcata*, Yellow Sickle Medick. This is a smaller plant than the last, and is suited to soils lower in the scale of fertility. It is cultivated on the poorer soils of Switzerland, and in different parts of Europe.

2. *Medicago lupulina*, Black Medick, so termed from the black colour of its seed-vessels when ripe. This is sometimes termed Yellow Clover, and sown by farmers under that name. It is also termed Hop Trefoil, from the resemblance of the heads of its flowers to those of the hop. It is an indigenous plant, and grows naturally on dry and gravelly soils. It is a biennial when cultivated. Like most of the leguminous plants, it is nutritive, but not so readily eaten by pasturing animals as the clovers. It may be cultivated for forage or for herbage, when the land is to remain only one year in grass.

3. Sainfoin.

Sainfoin, *Onobrychis sativa*, has a perennial root, is a native of Britain, and is extensively cultivated for green food in the chalk and sandy districts of England and France. Although this species has an extensive range of the lighter class of soils, it is yet, in a peculiar degree, adapted to the calcareous; hence it is found growing naturally in many open downs and hilly pastures where the chalk-formation exists.

Sainfoin is a deep-rooted plant, with a branching stem bearing spikes of beatiful flowers. It grows wonderfully on rocky soils, stretching its roots to a prodigious depth amongst the crevices of rocks and open strata. It is, in truth, on dry rocky soils that the chief advantages of the cultivation of sainfoin are seen. On a chalky rock, covered with only a few inches of soil, it will thrive and grow for many years with vigour, where neither corn nor cultivated herbage plants would cover the surface. Like lucerne, although in a lesser degree, it is choked, and ultimately extirpated by the prevalence of the grasses; but in a soil perfectly suited to it, as in a chalky down, it will have a duration perhaps as long as any other plant. Although best adapted to the calcareous soils, it will grow upon any light soil which has a free or open subsoil; but on moist clays it will only last a few years, sometimes not above two.

Sainfoin may be sown with a crop, in the same manner as the clovers and grasses. In the following season it may be mown for hay or green forage, although it does not attain its full maturity until the third year. When this mode of management is adopted, the sainfoin should be mixed with one or more of the clovers, of which the most suitable for the purpose is white clover, which will add to the weight of the produce, without materially interfering with the growth of the sainfoin.

When greater care is thought necessary, sainfoin, like lucerne, may be cultivated in rows, being regularly tilled and horse-hoed during the summer, and manured at intervals, as every fourth or fifth year; but for the most part, it is not thought necessary to resort to this method of tillage, and the easier and more convenient practice of broadcast is preferred.

The seeds of the sainfoin are larger than those of the clovers; and when sown with the cereal grasses in spring, a little more care is necessary in covering them with the harrow and roller. The seeds should be of a good and tried kind, and perfectly fresh, for old seeds do not vegetate in a proper manner. The quantity, when sown broadcast, may be 4 bushels to the acre; when sown in rows,

from 2 to 3 bushels. The best period of sowing it is in the month of March, although it is sometimes sown in February.

Sainfoin does not bear such frequent cutting as lucerne. When used for soiling, it may be cut twice; when used for hay, it should be cut once, and the aftermath depastured. Sainfoin may be used for herbage as well as for forage, and many farmers prefer depasturing it in the first year, so that in the second it may have attained its full growth before it is mown; and this is a good practice.

Sainfoin, when it is made into hay, should, like other leguminous forage-plants, be cut just when it comes into full flower. It is not very apt to be injured by heating, and therefore may be put up more quickly than other hay-plants. The produce in hay is generally reckoned from 1 to 2 tons to the acre, in districts where it is cultivated; and, considering that it is grown on inferior soils, and that it yields good aftermath, it will be seen to be a productive plant.

If ground is to be mown for successive years for forage, then, on such soils as are suited to it, scarcely a better crop can be cultivated than sainfoin, which is easily grown, hardy, and productive. But, with regard to this particular mode of cultivation, it cannot be at all commended. It is not the most beneficial mode of raising crops for forage; for, independently of the smaller produce, the keeping of land under any one kind of crop, and manuring it upon the surface, is to deprive the cultivated land of manures for an end which may be better attained by other means.

Sainfoin, when sown merely to produce one crop of hay, and then to be depastured for such a period as may be thought suited to the nature of the soil, answers well; but in this case, it is recommended that it be sown with a proportion of white clover and rye-grass. It is then merely a substitute for the red clover, and it is a good substitute, for it is a perennial, and will grow on soils on which the red-clover cannot be profitably cultivated. It is in this way only, it is conceived, that the cultivation of sainfoin

should be much extended in this country. It may be used as a substitute for red-clover, in many of the sandy, dry, and rocky soils of this country, which are intended to remain for several years in herbage.

Allied to sainfoin, is French Honeysuckle, *Hedysarum coronarium.* This is a perennial plant; but, when cultivated in this country, it becomes biennial. Its flower-stalks sustain spikes of rich scarlet flowers, sometimes white, which expand in June and July in the second year, and perfect their seeds in August or September, after which the roots decay.

This beautiful plant is a native of Italy, and other countries of the Mediterranean, where it grows in great luxuriance, affording excellent nourishment to horses, mules, and other animals. It is generally reckoned too delicate for field-culture in the north of Europe; but in our gardens it is seen to grow with surpassing beauty and luxuriance.

4. Wild Succory, &c.

1. The Wild Succory, *Cichorium Intybus,* is a native of the British Islands, as well as of many other countries. It is of the natural order *Compositæ.* It produces fine blue flowers, which open in the morning and shut in the evening. It is cultivated in many parts of Europe. In Lombardy and other parts of Italy, it is sown with other herbs, and esteemed as increasing the milk and flesh of cattle. It is there regarded as nutritious when made into hay; and is used for feeding horses and other cattle by summer soiling. In France and different countries, it is produced extensively for forage and other purposes, and enters into the regular rotation of the fields. Succory is doubtless capable of being rendered useful as a forage-plant. It is a native, and calculated to withstand the severest cold. It bears drought well, its large leaves covering the ground, and its roots striking deep into it. It grows with great quickness, comes very early in spring, and may be cut several times for forage in the year. If used for

soiling, it will be ready in all cases before clover; and this would be a great benefit, as the means of carrying on a system of soiling.

Succory may be cultivated like clovers, and sown at the same time with corn in spring; but the mode of growth of the plant, which is like that of the lettuce, points out a different manner of cultivation, as more suitable to it. This is by cultivating it by itself, and in rows.

Under this system, the plant could be easily tilled by the horse and hand hoe. It can be sown at any period from March to September, and when above ground should be hoed out to the same distance in the rows as carrots, parsneps, and similar plants.

In the second year, it may be cut for forage as soon as it is ready in spring, and the mowing repeated throughout the year two or three times, as the crop is ready. Care must be taken that it do not shoot forth its flower-stems and run to seed.

When the seeds are sown broadcast, either with or without a corn-crop, the quantity may be from 12 to 14 lb. to the acre; but when it is sown in rows, a much smaller quantity will be sufficient.

The principal use of succory, as a field plant, is for green forage; though it may be also depastured. It is not well suited for being converted into hay, as is practised in Italy.

2. Oriental Bunias, *Bunias orientalis*, has been recommended for culture for its leaves. It is of the family *Cruciferæ*, of which some, as the cabbage and the rape, have been already described, as yielding abundant green forage. The oriental bunias differs from these in being a perennial. It grows freely after being cut, though not with so much luxuriance as the succory. It is a plant of a very wide range of temperature and situation, growing from Arabia Felix to Siberia.

3. Prickly Comfrey, *Symphytum asperrimum*, is of a natural family noted for its mucilaginous produce and emollient properties, namely, *Boragineæ*. It is a native of the Caucasus. It is a perennial, is doubtless very productive, and is readily consumed

by animals in a green state, and grows freely after being cut. It is one of many plants worthy of further experiment, as are likewise two native species, *Symphytum officinale*, Common Comfrey, and *Symphytum tuberosum*, Tuberous-rooted Comfrey.

4. Common Cow-parsnep, *Heracleum sphondylium*, is a native plant of the family *Umbelliferæ*. It yields a plentiful supply of leaves in early spring, which are eaten by cows and other animals. It is of easy production, but has scarcely been introduced into cultivation. Others of the genus are yet more productive, and merit attention as forage-plants.

5. To this mixed class of plants may be added *Ulex europæus*, Common Whin, Furze, or Gorse. This is a shrubby plant, of which the soft shoots are cropped by animals; but it does not form the subject of cultivation in this country, though in some places where the plant is produced naturally, its young shoots are cut off, bruised, and given to horses and other live-stock. It is exceedingly nutritive, and well relished by animals fed upon it, and, in the absence of cultivated forage-plants, may be beneficially employed.

5. Clovers, Vetchlings, Melilots, &c.

Of the genus *Trifolium*, more than 160 species are enumerated by botanists, many of them deserving of the attention of cultivators. Those that are of most frequent cultivation for herbage and forage in this country are the Red and White Clovers.

Trifolium pratense, Red Clover, is a native species, and perennial, but the produce of that which is derived from France and other countries becomes, when cultivated in this country, biennial; though, by being prevented from running to seed, it frequently lasts to the third year or longer. As, however, in ordinary cases, it is only a biennial plant, that is, being sown in one year, and arriving at maturity and dying in the next, it is not well suited for permanent pasturage. But when the purpose is to keep the land one year only in forage or herbage, there is none

of the species of trefoils which has been found equal to the red clover for largeness of return and early maturity.

Trifolium repens, Creeping White Clover, is a native species, hardy, perennial, and suited to a variety of soil and climate. No plant known in the agriculture of Europe is so generally capable of cultivation as the white clover. There are varieties of it more or less nutritive and productive. It is usually mixed with the last species in cultivation, and these again with one or more of the grasses.

Trifolium hybridum, Hybrid Clover, was so named by Linnæus from his supposing it to be intermediate between the two last species. It is a native of the south of Europe, but has been introduced into the agriculture of Sweden and the north of Germany. It seems to be well deserving of the attention of the agriculturists of this country, being of larger growth than the creeping white clover, and like it a perennial. It might, therefore, form a substitute for the red clover in cases where land is laid down to perennial herbage.

Trifolium minus, Lesser Yellow Trefoil, and *Trifolium procumbens*, Hop Trefoil, are frequently cultivated under the common name of yellow clover. They are both annual plants, and, in practice, are often confounded with the black medick already described.

Trifolium medium, Zigzag Trefoil, is sometimes termed Cow-grass or Marl-grass. It is a native plant, perennial, and of easy culture. Its value, however, as a forage or herbage plant, is not very satisfactorily determined.

Trifolium incarnatum, Crimson Clover, is a native of the southern and central parts of Europe. The colour of its flowers is a beautiful red. But it is an annual plant, and as it must be sown in autumn, that it may flower and arrive at maturity in the following season, it is not so well suited to the system of agriculture practised in this country as the red and white clovers. A variety of this species termed *Molineri*, with pale flesh-coloured flowers, is later in flowering than the crimson clover, but does not otherwise differ from it.

Trifolium alexandrinum, Egyptian Clover, is like the last, an annual plant, and the same remark applies to it with regard to its suitableness for culture in this country. It is somewhat later than the crimson clover, but scarcely so productive of leaves.

It is not here necessary to enumerate other species of Trefoil. Those which experience has shewn to be suited to this climate, and the modes of agriculture practised, are the red and creeping white clover.

Lathyrus, Vetchling or Everlasting Pea, contains about sixty species, of which seven are native.

Lathyrus Aphaca, Yellow Vetchling, has been by some thought to merit attention as a forage-plant from the luxuriance of its growth. Its seeds, however, are said to be deleterious, which we have seen is the case with another of the genus before described as cultivated for its seeds, *Lathyrus sativus*.

Lathyrus pratensis, Meadow Vetchling, is common in thickets, moist meadows, and even in good pastures. Although recommended for herbage by Linnæus, Haller, and others, it scarcely appears to merit a place amongst the cultivated herbage-plants.

Lathyrus sylvestris, Narrow-leaved Everlasting Pea, is a perennial plant growing in moist meadows. It has a strong root, and grows with great luxuriance, intertwining with and overpowering the plants around it. How far it is grateful or nutritious to pasturing animals, has not been sufficiently determined.

Lathyrus latifolius, Broad-leaved Everlasting Pea, is a well-known climber, with peduncles bearing many gay flowers. It has been suggested by botanists that it might be applied to agricultural purposes. The plant is perennial, and would yield an abundant produce; but experiments are yet wanting to shew how far, by its nutritive properties, it is calculated to become a useful forage-plant. It has broader leaves than the last, but does not differ much from it in habit. The two, if grown together, would probably yield a large return of provender.

The other native species do not require especial notice. Numerous foreign species might be mentioned, as yielding a great

produce in stems and leaves, but their uses for the purposes of the farmer have not been ascertained by experiment. Of the whole genus, it is to be observed that the characters are somewhat suspicious. The leaves and stems are often bitter, and some of their seeds, as those of *Aphaca* and *sativus*, slightly poisonous.

Melilotus officinalis, Common Yellow Melilot, King's Clover, or Hart's Clover, is a native species of easy culture, and though deemed annual, sometimes remains for more than one year in the ground. It is a tall plant, growing from 3 to 5 feet high and more, with a somewhat shrubby stem. It has a certain bitterness of taste, and a smell similar to that of sweet-scented vernal grass; yet it does not appear to be disliked by animals, and might be cultivated in certain cases for forage.

Melilotus leucantha, White-flowered Melilot, is likewise a native species, and of habits and character similar to the last, though often growing much taller. This plant grows with surpassing luxuriance in the countries on the Black Sea and the Caspian, where it is used for the food of horses and cattle.

Melilotus Macrorhiza, Long-rooted Melilot, is a native of Hungary, and is cultivated in some parts of Europe. It is a perennial plant, and might yield a considerable supply of green forage or herbage on certain sandy soils.

Lotus corniculatus, Common Bird's-foot Trefoil, is an abundant plant in the higher natural pastures of this country. It is perennial, and in the month of June is readily distinguished by its tufts of yellow flowers. It is a small plant in its natural habitat, but enlarges by cultivation.

Lotus major, Greater Bird's-foot Trefoil, is by some regarded merely as a variety of the last species; but its characters are distinct, and continue so when cultivated under circumstances precisely similar. Both these species, and especially the latter, merit some attention as herbage-plants.

Common Broom can hardly be mentioned as a leguminous herbage-plant, though its young shoots are eaten by stock; but, when old, they are too bitter to be used. One of the genus, however,

Cytisus alba, Spanish Broom, is used in the south of Europe as food for sheep.

6. Heaths, Sedges, and Rushes.

These may be said to constitute a class of herbage-plants; they are generally of very inferior nutritive properties, but, forming a large part of the unimproved pastures of the country, they are of interest to the agriculturist.

The Heaths, *Ericeæ*, cover a very large proportion of the high lands of this island, and are frequently found extending to the plains. They indicate very generally the existence of peaty matter in the soil.

Of the native species, the most abundant is *Calluna vulgaris*, Common Heath or Ling, which extends over all the primary and transition districts of this country. It is a bushy shrub, growing from half a foot to four feet in height. The branches of it afford shelter, and its seeds food, to numerous birds of the grouse kind. Bees collect honey largely from its flowers, and the honey is of a dark colour, and by many esteemed beyond that derived from the lower plains. Almost every part of the north of Europe abounds with this plant. It is used in some parts as dried fodder for cattle, and as thatch for covering houses and cabins. It is formed into ropes and other things for which straw is used: a decoction of it is employed for the purposes of tanning; a yellow colour is extracted from it for dyeing wool: and a species of ale can be made from its young shoots, mixed with a proportion of malt. In conjunction with the dried turf in which it grows, it is used in many places as fuel, though it is not so well suited for this purpose as the thicker strata of peat.

Sheep, goats, and cattle, will feed on the young shoots of this and other species; but they prefer the gramineous plants. In order to cause the young shoots to spring, it is a common practice to set fire to the heath. This should be done in regular di-

visions over a stock farm, so that successive portions of young heath shall be obtained for the pasturing stock. By regular burning and close pasturing with sheep, the heath becomes less in quantity, and the grasses supply its place. The process is slow, but often it is the only practicable mode of improving mountain heaths.

The *Cyperaceæ*, or Sedge tribe, contain numerous species, which often so nearly resemble the grasses in appearance that they may be confounded. They are found in marshes, ditches, and running water. They are found also in heaths, moist woods, and meadows; and certain species on sands, and on the sea-shore. They are a far inferior class to the grasses in their nutritive properties; for, while the grasses are noted for the abundance of sugar and fecula which they contain, the sedges are remarkable for the absence of these principles. They are frequently mingled with the grasses, and form a part of the sward of our natural meadows, and sometimes they intrude amongst our cultivated herbage-plants, when they are to be regarded as weeds. Sometimes, however, the plants of the sedge-family are important, from their covering large tracts of country, and affording an abundant coarse herbage. Thus, the Scaly-stalked Spike-rush, *Eleocharis cæspitosa*, grows on certain moors and moist heathy places in great profusion. In the Highlands of Scotland it is called Deer's-hair, and occupying extensive tracts almost exclusively, is valued on account of its spring and summer pasturage.

The cotton-grasses, too, *Eriophora*, are common in bogs, and send forth leaves very early in spring. They thus afford an early herbage in high countries for live-stock.

The *Junceæ*, or Rush-family, occur largely in the moister pasture-lands of this country. These plants are the most common indicators amongst us of wetness in the soil. They are all of an inferior class as herbage-plants, though they are cropped by cattle in their young state, and in the higher districts are frequently converted into hay.

The most common species in low wet meadows are, *Juncus*

conglomeratus, Common Rush, and *Juncus effusus*, Soft Rush. They are best got rid of by removing from the soil the wetness, whether of the surface or substratum, by draining.

A very common species in the elevated parts of this country is *Juncus acutiflorus*, Sharp-flowered Jointed-Rush. This species is abundant in peaty bogs, forming often the greater part of their herbage. It is familiarly known under the name of sprit or sprat. Though animals do not eat it readily, unless in the absence of better food, yet, being made into hay, it is eaten largely by the hardier kinds of cattle.

7. Grasses.

The most important of the herbage-plants of this and other parts of Europe are the grasses. Of these, however, many are of low nutritive and productive powers, and in cultivated grounds are held to be weeds. But some of the less valuable kinds require attention on account of their frequent occurrence, and their adaptation to soils low in the scale of fertility.

1. *Anthoxanthum odoratum*, Sweet-scented Vernal-grass. This is one of the earliest grasses of the spring, coming into flower about the middle of April, and ripening its seeds by the middle of June. It contributes mainly to give that delightful fragrance to new-mown hay, so familiar to us. It grows on almost every soil; it is not of itself remarkable for its nutritive qualities, nor does it seem to be peculiarly grateful to cattle, although eaten by them along with their other herbage. Its value is chiefly derived from its early growth, its hardiness, and its property of continuing till late in autumn to throw forth its flowering stems. It can scarcely form the subject, in any case, of useful cultivation.

2. *Alopecurus pratensis*, Meadow Foxtail. This is a very generally diffused species, being a native of Britain and of most parts of Europe. Its herbage is held to be nutritive, and it appears to be grateful to ruminating animals. It is a very early

grass, is perennial, and constitutes a considerable part of the richest of our meadows. It does not attain its full growth for several years, on which account it is not well suited to the alternate husbandry. The young plants, too, are so frequently the prey of insects, and the seeds are often so defective, that only an inconsiderable portion of them can be calculated on arriving at maturity. Notwithstanding of these things, this plant, on account of its early growth, its permanence in the soil, and the quantity and value of its produce, deserves to be cultivated when the land is intended for perennial herbage.

3. *Phleum pratense*, Meadow Cat's-tail. This species is a native of Britain, though it was first introduced into notice from Carolina. It is called herd-grass in America, and is greatly valued there as an herbage and forage plant. It produces abundance of foliage in early spring, and may be cropped till a late season. There is none of the grasses more easily cultivated. It is not a peculiarly good hay-grass, from the wiryness of its stem, and the shortness of its aftermath. But still it may be profitably cultivated for this purpose in conjunction with other grasses, and deserves to be cultivated in an especial manner when the purpose is to produce a sward of permanent herbage, or even when the land is to remain only one year in grass.

4. *Agrostis alba*, Marsh Bent-grass, is one of the species of *Agrostis* which grow on moist soils, and which, having generally creeping roots or stolons, form frequently troublesome weeds. It sometimes passes under the name of Black Couch-grass. When it takes possession of wet clayey soils, its roots penetrate to a considerable depth, and, from their vivacious properties, it is very difficult to extirpate them. In more favourable circumstances, the marsh bent-grass grows with broader leaves, and assumes the appearance of one of the superior grasses. It was under this form that it was introduced to notice as a beneficial object of cultivation, under the name of Fiorin Grass. It grows naturally in the moister soils, and extends itself sometimes to the extirpation of less powerful grasses, by its creeping roots and stolons. Its best property as a pasture-grass is the late period at which it

rises in the season, affording food when other grasses have ceased to grow, and in spring also it affords an early herbage. These properties may render it sometimes expedient to cultivate this plant in small quantity, mixed with other grasses, when the end is perennial herbage, and especially in the case of irrigated meadows; but otherwise it does not possess properties to entitle it to be ranked among the grasses deserving of cultivation.

5. *Holcus lanatus,* Meadow or Woolly Soft-grass, grows readily upon all soils, and especially the peaty. It produces a profusion of light seeds, which are easily dispersed by the wind; from which circumstance, when it is once introduced, the soil is with difficulty freed from it. It is disliked by cattle, and refused by them when other herbage can be obtained. Nevertheless, the woolly soft-grass is not without its useful properties. It is superior to the heaths and some of the bents of peaty lands. Its easy propagation, therefore, on such soils is in this respect beneficial, that a pasture-grass can be substituted for the inferior natural produce of the soil. Although the woolly soft-grass may therefore be sown on the poorer class of peaty soils, it ought to be excluded from those on which better kinds can be produced.

6. *Holcus mollis,* Creeping Soft-grass, is frequently mistaken for the woolly soft-grass, but is readily distinguished from it by its awned florets and creeping root. The herbage of this plant is soft and tasteless, and apparently more disliked by stock than that of the woolly soft-grass. It is a troublesome and impoverishing weed, which it should be the study of the husbandman in every case to extirpate.

7. *Arrhenatherum avenaceum,* Common Oat-like grass, is the *Avena elatior* of Linnæus, and the *Holcus avenaceus* of some other botanists. It is a coarse though a productive grass, growing rapidly after being cropped, and producing an early and plentiful herbage in spring. It has been found, upon analysis, to contain more of bitter and saline matter than other pasture grasses, and hence it has been inferred that it ought not to be cultivated without a large admixture of other grasses. The juster inference would be, that it should not be cultivated at all. The roots,

which are fibrous in the moister soils, become bulbous in the drier, and then the plant is a troublesome weed, difficult to be extirpated.

8. *Poa aquatica*, Reed Meadow-grass. This species grows in situations favourable to it to a great height. It is common in flat and fenny countries, on the banks of rivers and the margins of pools. In the fens of Cambridge and Lincoln great tracts are covered with this grass, which not only affords rich herbage in summer, but abundant crops of hay for winter forage. It contains a larger proportion of sugar than the best herbage-grasses, and is accordingly much relished by pasturing animals. It is, however, too purely aquatic in its habits to allow of any extension of its culture. It is well suited to the swamps and fens where it grows naturally, but can scarcely be cultivated beyond them.

9. *Poa fluitans*, Floating Meadow-grass. This plant is found in ditches, stagnant waters, and other moist situations, its stem growing from 1 to 3 feet high. Its seeds are the manna of the shops, and are gathered abundantly in Poland, Russia, and some parts of Germany, where they are used as food. It is found in New Holland, a country abounding in vast marshes. It has been thought by some that it might be cultivated in this country. It is to be believed, however, that it is too aquatic in its habits to admit of cultivation, except in cases where it could be partially covered with water.

10. *Poa annua*, Annual Meadow-grass. This species has an annual root. It continues to flower throughout the spring, summer, and autumn, and sometimes even in winter. It rarely attains, even in the most fertile situations, a height of 10 or 12 inches. It is, however, the most prolific of all the grasses. The only case in which we can suppose this species deserving of cultivation, is when other grasses had died out, and when, by being sown on the sward of these grasses in spring or autumn, the annual meadow-grass might be expected to afford a growth of herbage in a few months.

11. *Poa trivialis*, Rough-stalked Meadow-grass, is one of the

superior pasture-grasses, forming a part of our richest meadows. Its root is fibrous, and its stems are roughish, and hence its name. Rough-stalked meadow-grass is nutritive, and greatly relished by pasturing animals. It requires, however, situations somewhat sheltered and moist. In dry and exposed ground its produce is inconsiderable; and this circumstance must determine, in certain cases, the expediency of cultivating it.

12. *Poa pratensis*, Smooth-stalked Meadow-grass. This species is distinguished from the last by its having a creeping root, and by the sheaths of the stem being smooth to the touch. It comes early, but, in this respect, it is equalled by other grasses believed to be more productive, and after being cropped in summer it grows slowly. It is inferior to the last mentioned species, and it may be questioned whether it deserves to be reckoned amongst the superior pasture-grasses.

13. *Poa fertilis*, Fertile Meadow-grass, is a native of Germany, where it is esteemed one of the superior pasture-grasses. It grows in wet situations, and near rivers. It is said to perfect its seeds abundantly. Experiments, however, are yet wanting, in this country, on the value and uses of this species.

14. *Dactylis glomerata*, Rough Cocksfoot. This is a coarse but very nutritive grass, of early and rapid growth. Although a native of Britain, its seeds were introduced from Virginia about the year 1780. It was not, however, cultivated till many years afterwards. It is justly held to be amongst the superior pasture-grasses, and is suited for forage as well as for herbage. It is more nourishing in spring than in autumn, and requires to be closely cropped: for, when suffered to grow, it rises in tufts and patches, and loses greatly of its nutritive properties. Oxen, horses, and sheep, eat this grass eagerly. Cocksfoot should always be sown in combination with other grasses, as the rye-grass, the meadow-fescue, and the other finer grasses.

15. *Cynosurus cristatus*, Crested Dog's-tail, has a wide range of soils and situations, and is plentifully produced in most of our natural pastures. It flowers somewhat late, and its culms, when it perfects its seeds, become hard and wiry, and are rejected by

pasturing stock. Although slow in arriving at perfection, late in flowering, and not very productive, this grass, on account of its easy culture, and the thick sward which it tends to produce, has been recommended for cultivation. This, however, should only be on inferior sheep-pastures, for the plant is not to be regarded as one of the superior grasses.

16. *Festuca ovina*, Sheep's Fescue-grass, is one of the smaller grasses growing on dry light elevated grounds. It is entirely an herbage-plant, and is only referred to here because botanists have spoken of it with approbation. It is a grass, however, which there can be no object in cultivating on arable soils in this country. The business of the farmer is to stock his pastures with the best grasses which they are capable of producing; inferior kinds will quickly tend to occupy the ground.

17. *Festuca duriuscula*, Hard Fescue-grass, is likewise one of the small grasses suited to the pasturage of sheep. It prevails on the lighter soils, but is found also in good natural pastures. It is superior in size to sheep's fescue; and may in some cases be sufficiently productive to deserve cultivation.

18. *Festuca loliacea*, Spiked Fescue-grass, grows in moist meadows, and is said to be very productive; but experiments are yet wanting on its value as an agricultural plant. It rarely with us perfects it seeds; which, however, would not be an objection to its cultivation were it otherwise useful, since seeds, in sufficient quantity, might be obtained from other countries.

19. *Festuca pratensis*, Meadow Fescue-grass, is justly ranked amongst the superior grass. Although a large it is not a coarse plant, and does not, like some of the other larger grasses, form tufts in growing. The leaves are succulent, and readily eaten by the larger pasturing animals. Its root is perennial and fibrous. It is found in the natural meadows of our richer clay-land vales, and may form a part of the pasture of all land of tolerable quality, laid down to perennial herbage. It requires, however, a longer time to arrive at its full maturity than some others of the superior pasture-grasses, as the cocksfoot, and is, therefore, less suited than they to the alternate tillage.

20. *Lolium perenne,* Perennial Darnel or Rye-grass, is one of the most important of the gramineous herbage-plants. It is the most generally cultivated of the herbage-grasses in Europe. This circumstance it owes to its early maturity, to its wide range of temperature and soils, and to the abundance and facility with which it can be raised from its seeds.

However valuable the rye-grass from these qualities be, it wants certain properties which others of the grasses possess, and a good permanent meadow, therefore, will be best procured by imitating the natural process of mixing grasses together. In this manner, the different kinds coming into flower at different periods of the year, will better afford a succession of herbage throughout the season.

The characters of this plant are greatly modified by the effects of climate, soil, and culture, and this has given rise to numerous distinctions, founded on the supposed qualities of the different sorts. The value of these to the agriculturist is mainly determined by the number and broadness of their leaves, their permanence in the soil, and the vigour with which they grow.

There are two kinds, however, which must be distinguished from one another in practice. The one flowers for successive years, and is therefore termed perennial; the other flowers in the second year, and, having borne its flowers, the root decays. This is, therefore, a biennial plant, but it is generally termed annual rye-grass. It is more productive than the perennial kind in the year after being sown, and hence, when the purpose is to retain the land only one year for a crop of herbage or forage, the shorter-lived variety is to be preferred. There are no means of distinguishing the biennial from the perennial kinds by their seeds alone, and great losses have been frequently sustained by mistaking the one for the other, when the purpose has been to keep the land for several years in grass. When the land is to remain for more than one year in grass, the perennial kinds must be sown.

Rye-grass should always be sown with some of the clovers. Mixed with the red clover, as will be afterwards seen, it is well

suited for hay. No other mode has yet been discovered equal to this for producing a crop of hay with certainty and economy, as the experience of farmers in the north of England, in Scotland, Flanders, and other parts of Europe, testifies.

21. *Lolium Italicum*, Italian Rye-grass, is cultivated in Italy, and other parts of Europe. It is probably, in most cases, of biennial duration, but by being cropped or mown before flowering, it may remain for several years in the ground. It reproduces itself freely from its seeds, which are scattered immediately on their becoming ripe. It grows with greater luxuriance than the common rye-grass, and its nutritive properties may be inferred from the eagerness with which it is eaten by animals. It appears to be a very valuable herbage-plant; but its permanence in the ground cannot be depended on.

It thus appears, that the native grasses which experience has fully shewn to be of the superior class, of permanent duration, and suited to culture, are:—

1. Alopecurus pratensis—Meadow Foxtail.
2. Phleum pratense—Meadow Cat's-tail.
3. Festuca pratensis—Meadow Fescue.
4. Poa trivialis—Rough-stalked Meadow-grass.
5. Dactylis glomerata—Rough Cocksfoot.
6. Lolium perenne—Rye-grass.

8. Burnet, &c.

Burnet, *Poterium Sanguisorba*, has been frequently recommended, and partially cultivated, as an herbage-plant. It is of the Rose family. It grows naturally on dry and calcareous soils, with a stem of about a foot or more in height. It is a very hardy perennial, remaining verdant during the winter, and yielding an early spring food. It is this that constitutes the sole value of burnet on the inferior class of calcareous soils on which it grows, for, in weight of produce and nutritive properties, it cannot be compared with the clovers and other leguminous herbage-plants.

The Corn Spurrey, *Spergula arvensis,* is cultivated in some countries for herbage. It is of the Pink tribe of plants, and is a native of the Old and New Continents, growing about Quebec, and the River Columbia, and plentifully in the gardens and fields throughout Europe. It is termed Spergula, or Spergularia, from the property which it possesses of spreading its seeds. It is by all foreign writers extolled as being very nutritious, and giving a rich flavour to butter. It is valued for its rapid growth. Being sown on the stubble in autumn, it will produce a crop in the same season. It is with us, however, regarded as a weed, and, from the smallness of its produce, can be of no value as an herbage-plant under the system of agriculture pursued in this country.

The Yarrow, *Achillea Millefolium,* of the natural family *Compositæ,* is a plant which is found in our richer meadows, and is closely eaten by pasturing animals. The yarrow has, on this account, been cultivated along with other herbage-plants, though with what precise benefit has not been well determined.

Ribwort Plantain, *Plantago lanceolata,* has been extensively cultivated in this country as an herbage-plant, under the name of Rib-grass. It is easily raised, and is eaten in its young state by pasturing stock; but no experiment has yet shewn that it ought to take the place of gramineous and leguminous plants of known value.

Of the various plants which have been enumerated, some are chiefly adapted to forage, some to herbage, and others may be employed partly for forage and partly for herbage. Several of the forage-plants, from their habits of growth, are best cultivated by themselves, or with a very slight intermixture of stranger plants. Of this kind are the tare and other vetches which are mown for forage; lucerne, sainfoin, when used for forage; wild succory, and others. The trefoils, again, and the other smaller leguminous herbage-plants, are best mixed with

some of the grasses ; and it is a point of useful practice, to determine what kinds should be selected, and in what proportions they should be mixed.

The most frequently employed of the leguminous plants for mixed forage and herbage are the red and white clovers, and of the indigenous grasses, rye-grass. This grass is well suited for general culture, arriving more quickly than most of the others at maturity, producing abundance of seeds, at all times easy to be obtained, and growing well under the shade of corn. For whatever period, then, land is to remain in grass after being sown, it will generally be well to sow such a quantity of the seeds of the rye-grass as will produce a crop of that grass alone, independently of the other grasses which may be mixed with it.

If the land is to remain for only one year in grass, then the rye-grass alone will be sufficient to form with the clovers good forage and herbage ; yet it will add to the value of the produce even for a single year, to sow it with a small proportion of the seeds of any of the indigenous grasses ; and of these, the best for this especial purpose is the meadow cat's-tail, because it is the most easily propagated, and arrives the soonest at maturity.

There may be sown 20 lb. of these two grasses in all, and 10 lb. of red and white clover, of which four-fifths may be red clover. The proportions may be—

Rye-grass, . . .	17 lb.	
Meadow Cat's-tail, . .	3	
	—	20 lb.
Red Clover, . . .	8	
White Clover, . .	2	
	—	10
		—
		30 lb.

A mixture in these proportions will yield a good produce for one season, whether it is used as herbage or forage.

But if the land is to remain for more than one year in grass,

then a mixture may be made of such of the other superior grasses as can be procured; while the quantity of the red clover may be diminished, and some other of the leguminous herbage-plants mixed with the clovers. We may sow in this case 12 lb. of the rye-grass seeds, which in most cases will be sufficient to secure a crop of this plant alone; and we may sow the other grasses in such quantity that the whole shall amount to 24 lb. The following may be the proportions:

Meadow Foxtail,	$3\frac{3}{4}$ lb.	
Meadow Cat's-tail,	$\frac{1}{2}$	
Rough Cocksfoot,	5	
Meadow Fescue,	2	
Rough-stalked Meadow-grass,	$\frac{3}{4}$	
Rye-grass,	12	
		24 lb.

To which are to be added:

Red Clover, or Hybrid Clover,	2 lb.	
White Clover,	6	
Bush Vetch, Tufted Vetch, or other perennial leguminous herbage-plants,	2	
		10
		34 lb.

In the preceding mixture of grasses, the quantity of rye-grass is equal to about half a bushel; and with regard to the other grasses, the proportions are such that each will, in ordinary circumstances, produce an equal number of plants. These proportions are obtained by computing the number of seeds in a given weight, and the number of each which, on an average, is found to vegetate.

Were it wished that the rye-grass should be merely in proportion with the other grasses, and that each kind should produce an equal number of plants, the following would be nearly the proportions:

Meadow Foxtail, . , .	$5\frac{3}{4}$ lb.
Meadow Cat's-tail, . . .	1
Rough Cocksfoot, . . .	$7\frac{3}{4}$
Meadow Fescue, . . .	3
Rough-stalked Meadow-grass, .	$1\frac{1}{4}$
Rye-grass, ...	$5\frac{1}{4}$
	24 lb.

8. Weeds of Agriculture.

The plants which have been described are those which form the subject of especial cultivation. The weeds of agriculture are those which grow among the cultivated plants, and which it is the province of the farmer to destroy. The prevailing plants of this class vary in every country, and in different parts of the same country.

Weeds may be divided into two general classes: those which propagate themselves solely by their seeds, and which, having once flowered, perish; and those which have perennial roots, and flower and bear seeds for successive years. The first are annual or biennial plants, according as they require one or two years to complete the period of their vegetation. The second are perennial plants, and grow again from their roots, as well as propagate themselves from their seeds.

In the case of annual or biennial weeds, if the stem is destroyed at the time of flowering, or just before it, the individual is destroyed, and its further means to propagate the species are taken away; but in the case of perennial weeds, the destruction of the stem does not infer the destruction of the plant, because the plant has the power of propagation from the roots. From this distinction, it would seem more easy to destroy annual than perennial weeds, yet this conclusion does not always hold; for some of the annual species have such numerous minute seeds, that it is often very difficult to extirpate them, and when they have got into

ground, keep possession even more inveterately than those which have the power of springing again from their roots.

Of the perennial weeds, greatly the most troublesome are those which have creeping roots; for these extend themselves below ground, and if any of the parts of the roots remain, these may give birth to new plants.

Either class of weeds may be frequently destroyed by the same means, namely, by assiduous tillage of the ground; but yet a natural division of them is into such as have annual and biennial roots, and such as have perennial roots.

1. Annual and Biennial Weeds.

Of weeds which have annual or biennial roots, the following are the most prevalent in this country:—

1. Sinapis arvensis—Wild Mustard.
2. Raphanus Raphanistrum—Wild Radish.
3. Papaver Rhœas—Corn Poppy.
4. Centaurea Cyanus—Corn Blue-Bottle.
5. Chrysanthemum segetum—Corn Marigold.
6. Pyrethrum inodorum—Corn Feverfew.
7. Sonchus oleraceus—Sow-Thistle.
8. Cnicus lanceolatus—Spear Plume-Thistle.
9. Arctium Lappa—Burdock.
10. Agrostemma Githago—Corn Cockle.
11. Stellaria media—Common Chickweed.
12. Spergula arvensis—Corn Spurrey.
13. Galium Aparine—Goose-grass.
14. Urtica urens—Small Nettle.
15. Lamium purpureum—Red Dead-Nettle.
16. Galeopsis Tetrahit—Common Hemp-Nettle.
17. Euphorbia helioscopia—Sun-Spurge.
18. Polygonum convolvulus—Climbing Buckwheat.
19. Polygonum aviculare—Knot-grass.
20. Ervum hirsutum—Hairy Tare.
21. Lolium temulentum—Bearded Darnel.
22. Avena fatua—Bearded Wild Oat.
23. Bromus mollis—Soft Brome-grass.

1. The Wild Mustard, the Charlock of farmers, frequently springs up in vast abundance in fields of growing corn. It flowers in May or June, and as it ripens and sheds its seeds before harvest, it is difficult to extirpate it. Sometimes its flowers are cut off by a scythe or hook as they rise above the corn in spring; and sometimes they are pulled up from amongst the corn by the hand, which is an unsatisfactory and operose method. The row culture is, in an especial degree, beneficial in the case of this and similar plants, for the first crops of them can be cut down by the hoe in spring. But the period most suitable for destroying the wild mustard is during the summer-fallow and fallow-crops. Yet under any circumstances it is difficult to subdue it, its seeds lying for an indefinite period in the soil, until brought by the plough within the influence of the air. Often it springs up without any known cause, and covers entire fields. It abounds in fields of turnips, contending for mastery with the young plants. Other species of sinapis also spring up in cultivated ground, but this is the most prevalent and hurtful.

2. The Wild Radish, or Jointed Charlock, like the wild mustard, has yellow flowers, and grows and sheds its seeds amongst corn. The two plants, from their similarity, are frequently confounded together, and pass under the common name of charlock.

3. The Corn Poppy is distinguished in summer by its gay red flowers. It sometimes rises in large quantities in corn-fields, especially in soils that are dry, sandy, or gravelly. It receives the name of red poppy, corn-rose, red weed, &c.

4. The Corn Blue-Bottle is of a genus which contains several species known as weeds. That, however, which is peculiar to corn-fields is the corn blue-bottle. It grows amongst corn, but rarely in great quantity, and its presence merely indicates careless farming.

5. The Corn Marigold is of a genus that supplies our gardens and greenhouses with many beautiful flowers. From the colour of its flowers it is in some places termed yellow bottle, in other places gowlands, or yellow gowans. It grows amongst fields of corn, and may be pulled by the hand. It is not in this coun-

try a very generally diffused weed, being found only in particular parts. But in some sandy districts of Europe it prevails to so great a degree as to destroy the crops.

6. The Corn Feverfew or Scentless Mayweed, is generally classed by farmers under the name of Mayweed, with two other plants of similar appearance, Stinking Chamomile and Wild Chamomile. The corn feverfew rises sometimes in cultivated land in considerable quantities.

The corn poppy, the corn blue-bottle, the corn marigold, and the different mayweeds, may be said to form a class. They grow up with the crops of corn, and announce, by their beautiful flowers, the return of the warmer season. They are not of the formidable class of weeds, and yet assiduous tillage is required to eradicate them. They are frequently conveyed to the farm with the seeds of corn, and then careful winnowing is the best preventive.

7. The Sow-Thistle grows in fields of corn. It is of a family of plants whose light seeds are widely dispersed by the winds. But although a common, it is not a dangerous weed.

8. Spear Plume-Thistle is one of a genus of troublesome weeds, but which are mostly perennial, while the spear plume-thistle is biennial. It sometimes abounds in old pastures. It may in all cases be destroyed by cutting it over when in flower, and before its seeds are ripe.

9. The Burdock is a familiar plant, whose hooked scales fasten themselves pertinaceously to clothes and the fur of animals. It is a biennial plant, seldom injurious, and easily extirpated.

10. The Corn-Cockle or Corn-Campion, is of the pink tribe of plants. The flour of its seeds mixed with grain injures greatly the quality. The seeds are heavy, and, on this account, cannot be separated from corn in the operation of winnowing. It grows singly, chiefly amongst wheat; and being easily distinguished, it can be pulled up by the hand.

11. Common Chickweed is of the same natural family, but of a different habit of growth. It grows not alone, but thickly in the parts of fields which are enriched by the dung of animals.

Under careless management it is often a troublesome weed; and, in fields of turnips, it will contend for mastery with the young plants.

12. Corn Spurrey, likewise of the Pink tribe, sometimes grows thickly in corn-fields, and then it indicates bad condition of the soil, or careless farming.

13. Goose-grass, called also cleavers, catchweed, and goose-tongue, grows naturally in hedges, but is carried also to the cultivated fields, where it propagates itself rapidly. Its seeds are furnished with hooked bristles, which attach themselves to the fur of animals, and in this manner are disseminated. In some parts of England it is a troublesome weed, but in other parts it is comparatively inoffensive.

14. The small Nettle is an annual plant. It sometimes extends over cultivated fields, and generally indicates that the soil is enriched by putrescent substances.

15. The Red Dead-Nettle, though termed a nettle, is of the Mint tribe of plants. It is thus of the same family as the mint, the marjoram, the sage, and the thyme, plants all harmless, and possessing cordial and stomachic properties. The red dead-nettle is sometimes common in fields, especially near hedges, and in sheltered places.

16. The Common Hemp-Nettle, also of the Mint tribe of plants, is common in corn-fields. Reapers are sometimes affected by severe inflammation in the hand by grasping it. It is covered by bristles, and these, on being pressed, emit a poisonous fluid.

17. Sun-Spurge is one of a family of plants which yield a peculiar milky juice. It is sometimes abundant in corn and turnip fields.

18. Climbing Buckwheat is in some places termed bindweed, or bearbind. When in quantity it is apt to overpower the corn. It is frequently seen twining round turnips and other plants. Its seeds are said to injure wheat; but the seeds are in themselves nutritive, and, if mixed with oats, will not injure their quality.

19. Knot-grass is another of the buckwheat genus, of frequent

occurrence; but it abounds more in waste places than in cultivated grounds.

20. Hairy Tare is a leguminous plant which frequently occurs in cultivated fields, and then it is a hurtful weed.

Several of the annual grasses are of frequent occurrence in cultivated grounds.

21. The Bearded Darnel is common in some countries, but it is comparatively rare in this. It has been condemned as a poisonous plant for more than 2000 years.

22. The Bearded Wild Oat is often a very pernicious weed. Its seeds readily drop out when ripe; and as it ripens sooner than the cereal grasses, and then sheds its seeds, it is difficult to extirpate it. It is frequently conveyed with the seed-corn to the ground, and thus may be propagated on the best managed farms.

23. Several of the Brome-grasses are found as weeds in our corn-fields. The most frequent of these is the Soft Brome-grass, in some places termed goose-grass. The seeds of this plant are like those of rye-grass, and are propagated along with that grass. But the plant itself is easily distinguished from the rye-grass; and when the latter is to be thrashed for seeds, the Brome-grass may be picked out by the hand.

The list of this class of weeds might be greatly extended, but this does not seem to be here necessary. They are all of them best extirpated by diligent tillage. The better cultivated a country becomes, the less prevalent and hurtful will be this class of plants.

2. Perennial Weeds.

1. Ranunculus acris—Upright Meadow Crowfoot, and other Ranunculi.
2. Senecio Jacobæa—Common Ragwort.
3. Tussilago Farfara—Coltsfoot.
4. Bellis perennis—Daisy.
5. Chrysanthemum Leucanthemum—Great White Ox-eye.
6. Cnicus arvensis—Corn or Way-thistle.

7. Centaurea nigra—Black knapweed.
8. Sonchus arvensis—Corn Sow-thistle.
9. Lamium album—White Dead-nettle.
10. Rumex obtusifolius—Broad-leaved Dock.
11. Polygonum amphibium—Amphibious Persicaria.
12. Urtica dioica—Great Nettle.
13. Agrostis alba—Marsh Bent-grass.
14. Arrhenatherum avenaceum—Common Oat-like Grass.
15. Holcus mollis—Creeping Soft Grass.
16. Triticum repens—Common Wheat-grass.
17. Juncus effusus—Soft Rush, and other Junci.
18. Ericæ—Heaths, and other shrubby plants.
19. Filices—Ferns.
20. Musci—Mosses.

1. The Upright Meadow Crowfoot grows in a great variety of soils and situations. Like most of the dangerous family to which it belongs, it inflames and blisters the skin. It is too acrid to be eaten by cattle, unless largely mixed with other plants; but so mixed, it is consumed in small quantity, and, from its abounding in our meadows, is perhaps designed to serve as a condiment. In common with some others of the genus, it is termed butter-cup, or butter-flower, from a popular notion that it gives the yellow colour to butter. It, however, injures the butter, whose yellow colour is due to the richness of the pastures, and not to these acrimonious plants.

The Creeping Crowfoot, *Ranunculus repens*, and Bulbous Crowfoot, *Ranunculus bulbosus*, resemble the last in their properties. They adorn our meadows with their bright yellow flowers, and are comprehended under the common name of butter-flower, buttercup, and sometimes of king's-cup, golden-flower, &c. The breaking up of grass land for a course of tillage is the only means of eradicating this class of weeds.

2. Common Ragwort is a large well-known weed in pasture fields. It receives many names, as ragwort, ragweed, cankerweed, &c. It has a perennial root, and grows to the height of 2 or 3 feet. It is best kept down by pasturing with sheep, which eat it in its early stages. By being pulled up by the hand, which can be easily done when the ground is soft from rain, it can be

extirpated in grass fields without taking up the land for a course of tillage.

3. Coltsfoot grows chiefly in moist clays, and especially in very marly soils. Its broad leaves overspreading the surface, it is very hurtful where it prevails. Tillage and draining, and improving the texture and fertility of the soil, are the means to be adopted for rooting it out.

4. The Daisy, though everywhere loved and admired as the harbinger of summer, and the ornament of our fields, is, in the judgment of the farmer, a weed. Where it prevails too greatly, the land requires to be renovated by a course of good tillage, and by lime.

5. The great White Ox-eye, sometimes also called the great white daisy or moon-flower, often abounds in pastures, and is only to be extirpated by tillage.

6. Thistles form a class of weeds very formidable to the agriculturist, from the ease with which they are disseminated by means of their downy seeds, and the difficulty of eradicating them. Some of them have deep vivacious roots, and all of them, on account of their vigorous growth, and strong spreading leaves, are injurious amongst the cultivated plants.

The most common of the thistle kind is the corn or the way-thistle. This plant has strong, creeping, and vivacious roots, the habit of which is to strike down to a great depth in the ground. If any parts of these roots are left in the soil, they will again give birth to numerous plants.

The means of extirpating the way-thistle from land is by a continued tillage and deep ploughing. Even an efficient year's summer fallow will not always effect this; for when land has been thoroughly overrun by the plants, they will spring up in future years, and require successive years' tillage thoroughly to exterminate them. The lands of various parts of this country used to be greatly more covered with thistles than they now are. In some parts of Scotland they were once so abundant, that they used to be cut regularly for five or six weeks in summer to supply food for the wretched cattle of the day. In well-cultivated

districts they have been got under, though so great is their tenacity of life and power of propagating, that they demand constant attention on the best-cultivated farms, and, under negligent management, never fail to take possession of the soil. New lands brought into cultivation are often entirely covered with this species, and a course of tillage is necessary before it can be subdued.

In the ordinary management of the farm, thistles will sometimes spring up in great abundance with the first crop of oats after grass. In this case, they must be weeded early in summer, by being cut over near the surface, which is conveniently done by the weed-hook (Fig. 136). The sole effect of this, however, is to retard the growth of the plant, and prevent it from running to seed, or contending for mastery with the growing corn.

Thistles sometimes spring up in great plenty in old pasture-fields. In this case, they should be cut close to the ground at least once a-year, so as to prevent their smothering the pasture-plants and running to seed. But it is only when the land is broken up for tillage that effectual means can be used for destroying them. Instruments, indeed, have been devised for pulling up thistles from the ground, but the roots of the plant are too easily broken, and the smallest portion left in the soil will spring up.

The thistle not only grows from its creeping vivacious roots, but is widely disseminated by its light downy seeds. Thistles, therefore, ought to be cut down before being permitted to perfect their seeds; and they should never be suffered to grow in waste places and hedges, whence their light seeds may be carried to poison the neighbouring fields. Further, when they have been cut down at an advanced stage, they should not be left on the ground, for, like many Compositæ, they will mature their seeds though separated from the ground.

7. Black Knapweed is one of a class of thistle-like plants. It is termed horse-knot, and receives many other local names. It is a hurtful weed in pastures where it prevails, increasing much by the roots, and being extirpated with difficulty.

8. The Corn Sow-thistle is a frequent plant in corn-fields, distinguished by its tall stems and large yellow flowers; but it is not usually a very hurtful weed.

9. The White Dead-nettle is occasionally common in corn-fields. Having a strong, creeping, perennial root, it should be carefully extirpated. This is one of the Mint tribe of plants before referred to.

10. The Dock genus comprehends a variety of species known to the farmer as weeds. These plants produce a large quantity of seeds, which they readily mature. The seeds are heavy, and, though diffused by the smaller birds, to which they serve as food, they are not so readily disseminated by the winds as those of the thistle kind. They, however, vegetate freely when they fall on the ground, and produce plants, which, when once allowed to extend their roots into the soil, it becomes difficult to exterminate. The roots are vivacious, and, if cut in pieces, the separate parts will send forth shoots. It is more easy, however, to raise up the roots of docks than of thistles by means of instruments, which receive the lower part of the stem in the cleft, and being used as a lever, wrench the plant from the ground. But the only effectual method of extirpating docks, as of most other weeds, is by summer-fallow or cleaning crops. The seeds of docks are often conveyed to the farm mixed with grass-seeds. When this takes place, the docks will frequently establish themselves with the grasses, and grow vigorously the second year. They should be then pulled up by the hand, so as to prevent their running to seed, and further overspreading the ground. The species of docks are very numerous. The most common is the broad-leaved dock, which is found in every country of Europe. In this country, it generally indicates a good soil.

11. Amphibious Persicaria is of the same natural family as the docks. On damp deep soil it is sometimes very abundant, overspreading the surface when the land has been left in grass. The prevalence of this plant generally indicates the need of draining.

12. The Great Nettle is frequent in waste places, under walls, and in hedge-banks. This species grows over all Europe, and is

found from Barbary to Siberia and Japan. In this country it generally indicates a good soil. When it takes root in pastures, it is very difficult to extirpate it. It forms patches on which other plants will not grow. It may sometimes be destroyed by cutting the plant, so as to enfeeble it, and sometimes it is dug up by the roots. But when it prevails in pasture grounds to any extent, the proper remedy is a course of tillage.

Several of the grasses are known as weeds, which, from their creeping or vivacious roots, it is difficult to extirpate.

13. The Marsh Bent-grass extends itself not only by its creeping roots below the surface, but by its stolons or suckers above ground. Others of the genus extend themselves in the same manner in wet situations. They receive the names of black couch, black twitch, or black wrack.

14. The Common Oat-like grass has bulbous roots, whence it is called by farmers knot-grass. It is a very troublesome weed in many soils. The little bulbs, when detached from the root, grow again, so that very careful tillage is required to extirpate the plant when it takes possession of a piece of ground.

15. Creeping Soft-grass is another plant, which, when it takes possession of ground, is not easily rooted out. It has a strong creeping root; but the species is comparatively rare.

16. Common Wheat-grass or Couch-grass, is called likewise quick or wrack, and receives many other names. It is the most abundant of the perennial weeds of corn-lands. Its roots are creeping, and every part of them left in the ground will grow; and hence the difficulty of extirpating the plant. The most effectual mean of doing so, is by frequent ploughing and harrowing, and collecting the roots by the hand. This constitutes, as was formerly seen, an important part of the process of the summer-fallow, and preparatory cleaning crops. There is no weed which requires so constant a vigilance on the part of the husbandman as the creeping wheat-grass; but it is well that, in contending with this perpetual enemy, he is compelled to give a more assiduous tillage to his land than he might otherwise be induced to do.

These different grasses are frequently all confounded under the name of couch, quick, and wrack,—names sufficiently indicating their characters.

17. The Soft Rush, with other Junci, are all to be regarded as weeds when they prevail amongst the better plants. They indicate wetness, and are only to be effectually removed by draining.

18. The Heaths are a widely extended family, covering a large part of the north of Europe. Where they intrude amongst the cultivated plants they are to be regarded as weeds.

Many other shrubby plants are found in unimproved land, and one of the first objects of cultivation is to extirpate them. Fallowing and liming are the usual means by which this class of plants is destroyed.

The Whin is one of the class of shrubby weeds. It requires continued culture thoroughly to extirpate it; for, after being apparently subdued, it will spring up again in great numbers, and for successive years. When the land is in grass, the young shoots may be sometimes pulled up by the hand, after the land has been saturated by rain. But when whins have thoroughly established themselves in the soil, and extended their roots, they must frequently be hoed up before the plough can act. The land being then ploughed with a good furrow, the remaining roots are torn up, and the plants at length destroyed. On elevated sheep-farms, whins should be encouraged rather than destroyed, for in such situations they afford shelter and food.

Broom is a shrubby plant, for the most part more easily extirpated than the whin, though in certain situations it grows with great pertinacity. It affects the lighter soils.

Brambles, and other shrubs of the Rose family, are often the possessors of unimproved soils. Certain species of the bramble are very tenacious of their situation. These plants are destroyed by the same means as the whin; and the like remark applies to all the larger shrubs.

19. Another class of weeds is the acotyledonous, or flowerless plants, at the head of which stands the Fern. Of the fern

or fern-like plants, there are many species in this country. They grow chiefly in mountainous tracts of natural pastures.

20. The last in order of the weeds are the Mosses. These plants are altogether innutritious. They often intrude extensively on pasture-ground, and supplant the herbage-plants. The best remedy in all cases is a course of tillage, and the application of lime.

The list of perennial weeds might be greatly extended. They differ in their characters and habits of growth, but they are all of them eradicated by careful tillage, chiefly during the period of the summer fallow and cleaning crops.

9. Management of Grass Lands.

1. Forage.

The produce of land which is designed for the feeding of animals may be consumed in three ways :—It may be eaten upon the ground where it grows ; it may be cut down and given to animals while it is yet green, which is termed soiling ; or it may be dried, in order that it may be preserved, when it is termed hay.

The plants employed for these purposes are the different forage and herbage plants which have been enumerated, some of which are chiefly applicable to herbage, some to green or dried forage, and some to either of these purposes.

The clovers and similar leguminous plants mixed with grasses, may be applied alike to forage and to herbage. They form what, in common language, are termed the artificial or cultivated grasses ; and land, when producing them, is commonly said to be in grass.

The seeds of the grasses and leguminous plants are to be sown in spring in the manner before described, upon the surface of ground sown with the cereal grasses. When the crop of corn had been sown in autumn, the seeds of the clovers and grasses are sown in spring amongst the growing crop, the harrows passing over the surface with a double turn. When the corn itself

is sown in spring, the grass-seeds are also sown, just before the last turn of the harrows, and then the roller is frequently employed to complete the process. The seeds are sown either by the hand, or by the broadcast sowing-machine, which regulates better the quantity, and sows them with more regularity. Care must be taken that the seeds of the grasses be sound and of the proper kinds, and that those of the clovers be fresh and well ripened, which will be shewn by the shining appearance of the seeds; and great care must be used that those of either kinds be free from the seeds of weeds.

The proportion in which the different kinds of clovers and grasses may be sown together, is chiefly dependent upon the longer or shorter period for which the land is to remain in grass.

The seeds of the clovers and grasses may be sown in autumn as well as in spring, without any corn-crop; and this practice has been recommended, in the case of laying down land to permanent grass, as being calculated to afford a quicker and better sward: and so indeed it may do; but then it is by the sacrifice of a crop of corn, which is too great to be disregarded in the practice of the farm. Cases may exist in which the value of permanent herbage is so great, with relation to that of corn and other crops, that this sacrifice may be made; but, in the great majority of cases, the advantages to be derived from the practice will in nothing compensate the increased expenditure. There is no difficulty, under good management, of getting the seeds of grasses and clovers to vegetate under the shade of corn in sufficient quantity to stock the ground; and in the forming of the meadow, therefore, there can seldom be a reason for deviating from the simple and economical practice of sowing the seeds of the herbage and forage plants along with the crop of corn.

The seeds, when sown, quickly vegetate, the plants springing up under the shelter of the larger crop; and in autumn, when it is reaped, they will be seen to be covering the surface.

In autumn, the ground may be slightly depastured with sheep; but heavy cattle which would injure the surface, should not be put

upon it, and sheep only for a short time. During the period of winter, the land should remain untouched.

In the following season, the plants may be consumed in any of the three ways that have been mentioned:—

1st, They may be depastured with live-stock.

2d, They may be mown two or more times during the season for green forage, and the aftermath depastured.

3d, They may be made into hay, and the aftermath depastured.

When they are to be employed in the first of these ways, namely, for herbage, they may be depastured either by sheep or the larger cattle. Sheep may be put upon them in April or sooner, while they are yet short; but cattle should not be put upon them till the plants afford a full bite, which will usually be in May.

There is no period in the growth of these plants, at which they will afford so early and rich an herbage as in this, the second year after they are sown, or when, in the language of farmers, they are one-year-old grass. They will fatten the larger cattle perfectly. But it is to sheep that they are in a peculiar degree adapted; and, in the practice of the farm, the larger cattle are usually put upon the old grass, while the sheep are fed upon the young grass.

Whether, in any case, a field of young grass shall be applied to herbage or forage, is dependent on considerations of expediency and profit. If there shall be stock upon the farm requiring good and early grass, it may be most advantageous to use the new grass for herbage: in certain cases, it may be more advantageous to employ it in soiling; and in others, to convert it into hay; and in the practice of the farm, it may be applied to all these purposes.

When the grasses and clovers, or any other forage-plants, are to be used for soiling, they are mown with the scythe and carried directly to a house or yard, and put into a crib or rack, the animals being at the same time well littered with straw, so as to be kept dry.

A field of young grass intended to be mown is managed thus:

—When the land is sufficiently dry in spring, it is rolled so as to prepare the surface for the action of the scythe; and should any loose stones be upon the ground, they are gathered by the hand previous to rolling, and thrown into carts driven slowly along the ridges. Sometimes the ground may be too soft to bear the carts, and in this case the stones may be laid in little heaps in the furrows, until it is convenient to remove them. These operations should take place in the end of March, or as early as possible in April.

In the northern parts of the country, it is usually the beginning of June before the process of mowing can be begun, but in the southern parts mowing may commence several weeks earlier. The field, or part of a field, reserved for the purpose, is then mown daily in such portions as are required for each day's feeding, and the forage given in its green and juicy state to the animals. While the field, or portion of the field, is thus being gone over, a second crop will have been springing up. Beginning then with the part which had been first mown, the ground is again to be mown daily until it is passed over a second time. In this manner, two crops or cuttings will be obtained, and in favourable situations three. Should there be an interval between the cuttings, that is, should the second crop not be sufficiently ready after the field, or part of the field, has been passed over, then some food must be provided for the animals in the mean time. The best provision, in this case, is the tare, which is one of the reasons for cultivating this plant on farms where soiling is practised.

The practice of soiling has certain advantages over the more common system of allowing the animals to find their own food in the fields. Their provender is brought to them, and none of it is wasted by their treading it down, while they are freed from that disturbance to which all animals are subject in summer and autumn from insects. It is found, accordingly, that the larger animals feed well under this system, and that a smaller space of ground will be sufficient for feeding an equal number.

As a country becomes rich, highly cultivated, and populous,

soiling is the manner of feeding which will naturally prevail. Hence it is practised in this country in the neighbourhood of cities, where the land can be kept fertile; and it is the system adopted in some of the richer parts of Europe, and in an especial degree in the Netherlands, whence we have derived it.

But although soiling be the most profitable system of feeding where it can be adopted, yet in this country it is in many cases not practicable, and in certain cases not expedient.

The cases in which it is not practicable, are when land does not possess a sufficient degree of natural or acquired fertility to produce good and early crops of grass, or when sufficient straw to litter the animals during the period of feeding cannot be obtained. A large proportion of the land of this country will yield an adequate quantity of grass for herbage, but not sufficiently early and good for regular soiling.

The cases in which soiling is not expedient, although it may be practicable, are when the animals to be fed require exercise to keep them in health and in a growing state. Thus oxen are the better for moderate exercise in their first or second year. Young horses absolutely require it; and even milch-cows, although they may be fed in the house or yard, maintain their health better in the fields. To the habits of the sheep, the confinement of the house or yard is still less suited; and although in some parts of Europe the system of soiling sheep is practised, it makes no progress in a country abounding in pastures like Britain. A case in which soiling may be applied in all arable farms in this country is that of feeding the working-cattle of the farm.

The next and most common method of applying the sown grasses and clovers is as dried forage or hay, in which state they can be preserved and given to the stock in winter, or at other times.

When the sown grasses and clovers are intended for hay, the land is to be cleared of stones and rolled in spring, as in the case of green forage. And when the plants are in full flower, and before the seeds are ripe, or even before the flowers of the clovers have in any degree begun to fade, the crop is to be mown.

The plants, by the action of the scythe, are laid in swathes, with their heads lying pretty regular in one direction. The swathes lie for a short time to wither; and are then turned gently over by a fork, or the handle of the hay-rake, in such a manner that they shall not be broken and spread abroad. In twenty-four hours or more afterwards, they may be put into small heaps or cocks on every third or fifth ridge, according to the bulk of the crop, the ground being at the same time carefully raked.

It is a good practice to put up the hay green in these first cocks, and then to enlarge them by adding two together. If at this early stage they undergo a degree of incipient fermentation, it is no matter. It is in the later stages of the process that heating or fermentation may become hurtful.

When the hay has become dry in the cocks, the period of which will depend upon the weather, they are made into ricks in the fields. The cocks are dragged together by a horse with a rope, one end of which is attached to one of his traces, and the other end being put round the base of the cock, is fixed to his traces on the other side. He is then made to pull forward the cock to the place required; and in this manner two or more of them may be dragged forward at once.

The ricks are made by a person standing upon them to build and compress them. They are formed with a conical top, and are each bound down with a rope made of the hay itself. In this state they may resist a considerable fall of rain; but the hay is not to be suffered to remain longer in the ricks than is necessary to dry it in a sufficient degree to fit it for being stored in a larger stack. When the hay is sufficiently ready, which will be denoted by its feeling dry when the hand is thrust into the rick, it is carried in the large sparred cart (Fig. 55) to the place where the hay-stack is to be formed, which is most conveniently in the barn-yard, near the stables.

The hay-stack may be built in a circular or oblong form; the latter is the most convenient when the quantity of hay is large. A number of persons being placed on the stack to build, the hay

is forked up to them, and the stack, by the treading of their feet upon it, is compressed in proportion as it is raised. In twenty-four hours it will have considerably subsided, and in a day or two afterwards it is thatched with straw, and bound down with straw ropes; the loose hay of the exterior having been pulled carefully out all around, so that the whole shall present a neat appearance.

Hay, when put into a large mass of this kind will undergo a slight degree of heat; but in the case of the clovers and grasses, the slighter the degree of heat at this period the better, and hence the necessity of a previous preparation of the material as carefully as the state of the weather will allow.

Often great difficulty is experienced in the processes of the hay-harvest by the wetness of the weather. In such a case the farmer is obliged to watch the intervals of favourable weather, and employ every practicable means to forward the operations and securé the crop.

Some recommend the strewing of salt upon the hay, as the building of the stack proceeds. This is a good practice, as it corrects the tendency to fermentation, and renders injured hay palatable to stock.

In the making of hay, the great end to be aimed at is to prepare it as quickly as possible, and with as little exposure to the weather and as little waste of the natural juices, as circumstances will allow. When we are enabled to do this, the hay will be sweet, fragrant, and of a greenish colour.

It is not usual to cut more than one crop of hay from the same ground in the year, although the second crop of the grasses and clovers may also be made into hay. It is never, however, so good as the first crop in weight and quality; and, besides, the late period of the season renders the preparation of it difficult or precarious. For these reasons the proper system is to depasture the aftermath, and not to make it into hay.

Wherever the system of the cultivated grasses is perfectly understood, they will never be mown for hay more than once.

The first year's aftermath, and all the subsequent years' grass, so long as the land remains untilled, are to be used for herbage alone.

The produce of this kind of hay varies greatly with the quality of the soil and state of the season. About 2 tons per acre may be regarded as a good crop, but often the produce is greatly more, and then the crop is considered to be a great one. Hay, in the field-rick, weighs somewhat better than 112 lb. per cubic yard; after being compressed in the stack, it weighs from 140 to 180 lb.; and when old about 200 lb.

Clovers, besides being raised for pasture or soiling, are sometimes cultivated for their seeds. In this case the clover to be cultivated should be sown by itself, depastured with sheep till pretty late in May, and then allowed to grow and ripen its seeds. When the seeds are fully ripened, the crop is cut down and formed into very small cocks, which, after being thoroughly dried, are carried home, and put into stacks until thrashed. The process of thrashing is a somewhat troublesome one, from the difficulty of separating the seeds from the capsules. It is usually done by the flail; and the seeds may be winnowed in the same manner as grain, but with sieves adapted to the purpose. This species of cultivation, however, has narrow limits in this country. The crop is a great exhauster of the soil, and, from the late period of ripening and the extreme dryness to which the plants must be brought, it is a somewhat precarious crop, even in the more favourably situated parts of the island. For these reasons the greater part of the clover seeds consumed in this country is imported.

The grasses, too, are frequently cultivated for their seeds. In this case the particular grass to be cultivated should be sown by itself. It should be dried and stacked like a crop of corn, and thrashed and winnowed. When a crop of this kind is cultivated, it should be regarded as an exhausting crop, and the land treated as if it had borne a crop of corn.

Sometimes the seeds of ryegrass are procured by a more partial process. The hay being put into cocks in the usual man-

ner, it is thrashed just before being put into the larger ricks. The thrashing is performed in the field on a moveable floor of boards, placed upon a coarse canvass cloth. In this case the hay should be slightly beaten by a flail, so as to detach the best ripened seeds without too greatly injuring or breaking the stems. The seeds are then put into sacks, and carried to the granary, on the floor of which they are spread and turned over as occasion requires. When dry, they may be dressed; or they may remain mixed with the chaff till spring. The hay, however, is always injured where this system is practised, both because it is deprived of the seeds, and because it is necessary to allow the plants to stand for a longer time to ripen than would otherwise be required.

No method of producing hay has been found comparable to that of the cultivated grasses. Under this system, the forage-plants are cut when in their state of most luxuriant growth, and no manure is laid upon the surface in order to produce the hay; and the manures, being applied to the preparatory fallow or green crops, are covered by the plough, and rendered entirely available. Yet over the greater part of England, land is kept permanently in grass for the purpose of mowing it, manure being applied from time to time to the surface. This system has become the very habit of the country, and, by the general adoption of it, beyond a question a vast public loss is sustained. The practice of the cultivated meadow was probably introduced into England by the Romans, and at a long subsequent period was made more fully known by the Flemings; and yet by far the greater part of all the hay produced in this island is derived from perennial meadows, and thus an expensive method of production substituted over a whole country for one more cheap and efficient. Certain peculiarities in the state of property in England, the effect of tithes, and the relative expense of keeping land in tillage and under grass, seem to have contributed to this so general substitute of the natural for the cultivated meadow. From habit, too, a preference is given to the hay thus produced. It is supposed by many to be more suited to keep horses in wind; and it

may be so in the case of horses put to great speed, as the hunter and the race-horse; but, for the mere purpose of feeding, it cannot be doubted that the produce of the cultivated meadow, consisting of the superior grasses and clovers alone, in their young and most juicy state, must be greatly superior to that of the older grasses, mixed as they always are with a class of inferior plants. But if the large application of capital and the waste of land, for the production of this species of food, are to be regretted, in no other country are the farmers so diligent and so experienced in the management of the hay itself as in England.

The grasses to be mown are ready in the month of July, and they are cut down when the greater number of them have come into flower. When the land is of good natural quality, or when a ready command of manure exists, it may be mown every year for hay. But it is more common to mow it every alternate year, or every third or fourth year, according to its quality. It is then depastured in the intervening years, and in this way it is less exhausted than when mown every year.

Land subjected to this species of culture requires to be manured at intervals upon the surface. When it is mown every year, the manures should be repeated every second or third year; but when it is occasionally pastured, the manuring may be less frequent.

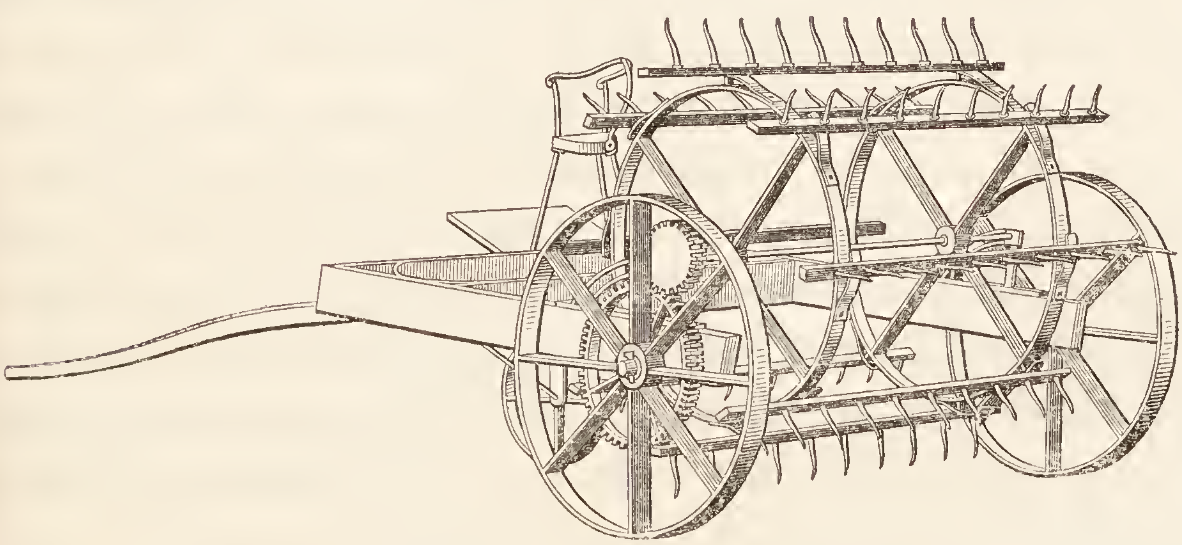
The manures used may be of all the kinds applied to land in tillage. That most commonly employed in practice is the common manure of the farm-yard, well rotted. This is spread thinly and regularly over the surface, generally at the rate of 7 or 8 tons to the acre. The period of laying it on is various; some preferring to spread it in October, others after the hay is cut in July or August, and some in spring.

The grass, when mown, is soon afterwards tedded, or spread abroad with a fork, so as to be exposed to the sun and air. It may be turned over one or more times, and while yet green put into little cocks. The manner of collecting the grass together is by raking it into rows, technically termed wind-rows, the hay-makers in bands following one another with rakes, until

they have thus collected the whole into rows. They are then easily able, by hand-labour, to form it into the small cocks described.

These first cocks are afterwards to be spread abroad, and, being exposed for a time, formed into larger cocks, termed sometimes bastard-cocks. In the county of Middlesex, where extreme attention is paid to the appearance and quality of this species of crop, the bastard-cocks are again spread abroad, and formed into yet larger cocks; after which they are carried home, sometimes on the fourth or fifth day. The object of this repeated spreading abroad, and forming into cocks, is to secure the hay in the shortest time, and with the least waste of its natural juices. This, indeed, is aimed at in all cases of making hay, but the details of practice are modified by the state of the weather, and vary in different parts of the country. Sometimes, to economise labour in these operations, hay-tedding and hay-raking machines are employed. The hay-tedding machine consists of a set of rakes placed horizontally. Motion being communicated to them from the wheels, by intervening pinions, they revolve in a direction opposite to that of the wheels, and, lifting up the hay, carry it round, and scatter it behind the machine.

Fig. 193.



Hay-raking machines are of different construction. One nearly similar to that represented in Fig. 144 may be used.

Although the raising of hay on the natural meadow must be

regarded as expensive, when compared with the raising of it on the cultivated meadow, yet there are soils and situations to which the practice is entirely suited, and in which it is the best method at the command of the farmer of obtaining dry forage.

One of these is the case of marshes, swamps, or bogs, producing naturally rushes, sedges, and the larger grasses. These marshes are of every degree of natural fertility, sometimes producing chiefly the *Carices* and *Junci*, and at other times producing the grasses of wet ground, as the *Poa aquatica*, *Poa fluitans*, *Agrostis alba*, and other plants of marshes.

The lowest for the most part in the scale of fertility of these wet grounds, and yet of great importance in the elevated districts where they abound, are those which consist of a thick bed of peaty matter. These are usually termed bogs, and the produce consists chiefly of rushes, as the sharp-flowered jointed rush, and others. This species of hay is greatly less nutritive than that of the cultivated or finer natural grasses. It is generally regarded as a little superior to the straw of wheat, barley, or oats, and will, for the most part, bear cutting but once in the year. It is too coarse for sheep, but is adapted to the winter provender of cattle. To these it affords a valuable resource in all the more elevated pasture districts of this country.

As the soil of the marsh improves, so for the most part does the natural produce which it yields. In flat and alluvial tracts the hay of the marsh is often valuable, even where cultivated forage can be otherwise obtained. It is frequently, therefore, a question of expediency, whether a marsh shall be broken up for tillage, or allowed to yield its natural plants. It may produce a great deal of manure without requiring any; it may furnish a valuable resource to wintering stock; and it may not be capable of being fitted for cultivation but by a considerable expenditure of capital.

The manner of preparing the hay of marshes is similar to that of preparing the hay of the grasses already described, except that greatly less nicety is required. The rushes or grasses, after lying for forty-eight hours or more, should be tedded well, so as

to receive the influence of the sun and air. After this operation, which is usually repeated once or oftener, the hay should be put into small cocks, and when sufficiently dried, put into ricks, to remain in them till the danger of fermentation is removed, when it may be carried home and formed into a stack. A slight fermentation in the stack may take place without injury, but care must be taken that this be not carried so far as to injure the hay.

There is another case in which perennial grass land, though not marshy, may be beneficially employed to produce hay. This is in elevated pasture districts, where cultivated forage cannot be obtained. In such situations hay must be procured for the stock during falls of snow, and then the only means of obtaining it may be to set apart a portion of the herbage-land for mowing. This is a case produced by the peculiar circumstances of sheep-farms; and it does not invalidate the general principle, that hay is best produced on the cultivated meadow.

One other method, indeed, of producing natural hay free from all objection on account of the waste of manures, is yet to be considered. This is Irrigation; but irrigation applies to the production of herbage as well as dry forage, and we may, therefore, first consider the management of land in the state of perennial herbage.

2. Pasturage.

Much of the land of this country has never been cultivated, but produces without cultivation the herbage-plants peculiar to it; such are all our mountain pastures, and the unimproved surface of the lower plains.

It is an error to apply the term waste to lands of uncultivated pastures. They are in no degree waste, but are employed in producing the species of food which, in the circumstances in which they are placed, may be the best which they are suited to produce. It may be supposed that, by cultivation, they will yield a

more abundant produce; but it is always a question of prudence, whether the profit in cultivating them will be greater than that derived from them in their natural state.

A primary improvement of which lands unsuited to cultivation are susceptible, is freeing them from stagnant water. This is for the most part to be effected by affording an outlet to the water in channels cut in the most convenient places. This should never be omitted where the land is of sufficient value to repay the expenses; and it is rare, when land is of sufficient fertility to produce the grasses at all, that the expense of giving an outlet to the surface-water will not be repaid by the increased value of the herbage-plants produced.

A species of draining, which has been practised to a great extent in some of the mountain districts of this country, is by means of narrow drains, about a foot in depth, made by the spade alone, carried along hollows and the sides of hills wherever the water is likely to be interrupted. By this species of draining, an important improvement, at no great expense, has been effected in many mountain pastures; and the tendency to rot, one of the most fatal disorders to which sheep-stock on wet lands is liable, lessened or removed.

Another method of improving the natural pastures of an elevated country is enclosing. In this way the animals of a farm are confined to the pastures which are suited to them, and permitted to feed undisturbed. And a great improvement of all elevated pasture-lands is shelter for the stock; and judicious planting, accordingly, is one of the means of increasing the value of exposed pastures.

But land is not only left in grass in parts of the country incapable of cultivation, or in cases where cultivation would not repay the charges incurred, but much even of the better land is kept in grass, when it is found that in that state it yields a more safe and steady profit than if cultivated. It is also, in all cases, a renovation of the productive powers of cultivated land to allow it to remain for a period in grass; and hence a large proportion of the whole country remains in that state.

The animals that may be pastured on all lands under grass are our different kinds of herbivorous stock. Cattle and horses require a large quantity, and, though they prefer the finer grasses, are satisfied with a coarser herbage than sheep. Hence, a rule of the farm is to put sheep on the finer and shorter grasses in preference to cattle and horses, and cattle and horses upon the larger and ranker pastures.

Whatever be the animals that are turned out to pasture, the rule is, that the pastures shall never be overstocked; that is, that there shall always be a sufficient quantity of food for the animals.

When animals are kept in the fields during the months of winter, they must of necessity remain there till the herbage rises in spring. But when they are not kept throughout the winter in the field, they are not usually put to the pastures in spring till these are sufficiently advanced to receive them. The usual period is April or May when our various animals are put into their respective pasture-fields for the summer.

The benefits of freeing lands from injurious wetness have been adverted to in the case of upland pastures. They are yet greater in the case of the pastures of the plains, inasmuch as the relative value of the land is greater. In this case, not only should surface water be carried away by ditches and open drains wherever necessary, but under-draining should be resorted to, to free the land of wetness. By removing underground water, a more valuable species of herbage is produced, and the tendency to produce inferior plants is lessened.

In the management of land kept in pasture, no manuring is required to maintain its fertility, which will be increased and not diminished by the effects of depasturing. Any species of manure, however, will add to the productiveness of land in grass; and when, from any peculiar cause, it is thought expedient to manure land in grass, the best kind of manure is usually lime, or composts of earth, lime, and other substances. These are simply spread upon the surface, when vegetation has become inert at the fall of the year, or before it has become vigorous in spring.

The surface of land kept in grass becomes uneven from se-

veral causes. One of these is of yearly occurrence,—the labour of the mole. In spring, the molehills should be spread regularly by the hoe or spade; and, to prevent the animals from becoming numerous, they are taken in traps.

Another creature, too, scarcely known in some parts of the country, but very troublesome in others, is the ant. The hills raised by the ants are unsightly and hurtful, and there is great difficulty in driving the little creatures from the habitation which they have so carefully constructed. The hills, forming little eminences like small hay-cocks, will sometimes cover a large part of the surface. The methods recommended for destroying the ants are, raising the sods containing them by the spade, and burning them in heaps; or, just before winter, dividing the ant-hill with the spade, and laying the contents upon the surface.

The chief injury, however, which land when left long in grass is apt to sustain, is the decay of its herbage by the springing up of inferior plants. The most common of these are the *Musci*, Mosses.

The mosses are altogether innutritious. They occupy the place of the herbage-plants, and thus render the pasturage of less value. They are most apt to grow where the soil is inferior and moist.

The best method of destroying this class of plants is by draining and liming; and old grass-land, when overgrown by these and other unproductive plants, should be taken up and undergo a course of tillage.

When it is inconvenient to break up the land, or when it is wished, for any good reason, to retain it in grass, the improvement of the sward may be attempted without tillage, although this will be found to be more expensive and less effectual. Rakes and harrows, with close-set teeth, may be employed to pull up the mosses; but this, which is merely a palliative, leaving the cause of the production of the plants unremoved, should be accompanied with draining, when necessary, and the application of calcareous matter to the surface. A somewhat more efficient mode of improvement is, to pare off the surface with the spade to the

depth of a few inches, and then, after stirring with the harrow the soil below, to replace the sod. The productive powers of old turf will be renovated by this process, and especially if any calcareous manure is applied before the sod is replaced.

When land is kept in grass, weeds of various kinds may tend to occupy the ground, in place of the more useful herbage. The smaller kinds of these can only be eradicated by improving the ground itself. The larger weeds, as thistles, docks, ragweed, and others, should be pulled up or cut over when they come into flower, or before it. The best instrument for the latter purpose is a little spade, carried in the hand, by which the stem of the weed is cut at or below the surface. The scythe, too, must be used, to cut down such plants as tend to overshadow the ground; and this should always be done before they have ripened their seeds. Whins, when old, must be hoed up, which is generally an unsatisfactory operation; but young whins may frequently, when the weather is moist, be pulled up by the hand. All suckers of trees, too, should be pulled up as soon as they appear.

The very detail of these circumstances, however, shews the expediency of taking up old turf for a course of tillage, whenever it tends to produce injurious plants. It is in this way only that they can be thoroughly eradicated, and their place supplied by better herbage.

3. Irrigation.

The fertilizing effect of water on the earth is one of those natural phenomena which everywhere force themselves upon the attention of mankind. Water is seen to be essential to vegetable life. In those climates where evaporation is the greatest, Nature has generally provided the most plentiful supply of this fluid in rains and dews. But the rains, often occurring at a particular season of the year, are insufficient for the life and nourishment of useful plants during the remainder, and the art of the irrigator is therefore necessary to produce fertility. Without the artificial

conveyance and distribution of water, some of the most fertile countries in the world could not have supported their inhabitants; and the earliest husbandmen accordingly knew and practised the watering of lands as an art. In Egypt, where the great inundation of the Nile soon taught the inhabitants the value and uses of irrigation, this art is known to have been practised on a scale of surpassing magnitude; and the canals and vast artificial lakes of that celebrated people, though less enduring, are more praiseworthy, monuments of their genius, than all the temples and cemeteries with which they have covered their country. From the valley of the Nile, it is to be believed, the knowledge of the art would be extended to many countries. To the Greeks and the Romans it was well known, and the rustic writings of the latter abound with allusions and rules relating to the watering of land. Without water collected by art, rice, which furnishes food to the greater part of the human race, could not be cultivated; and over the vast regions of Southern Asia, accordingly, the watering of land from rivers, brooks, lakes, and wells, is a labour essential to the support of the inhabitants. In all the southern countries of Europe, the art is more or less practised. It is there that the water is conveyed in little channels to the corn-fields, to the vineyards, and to the olive-trees. The conducting of it from rivers and canals, and measuring it out in determined quantities, form, in several parts of Italy, a nice part of the science of engineering. In Piedmont, and the whole valley of the Po, the water is frequently paid for by the hour, and the utmost care is bestowed in economising so precious a substance.*

The main object of irrigation, however, in all the intertropical countries, and in the warmer parts of the temperate zones, seems merely to be to convey to the ground that quantity of water which is necessary for the growth and nourishment of the plants to be produced. Sometimes, as in the case of rice, the earth must be saturated for successive months, and, in others, merely watered at intervals, during the periods of greatest evaporation. In all

* Paper by the Author in the Quarterly Journal of Agriculture.

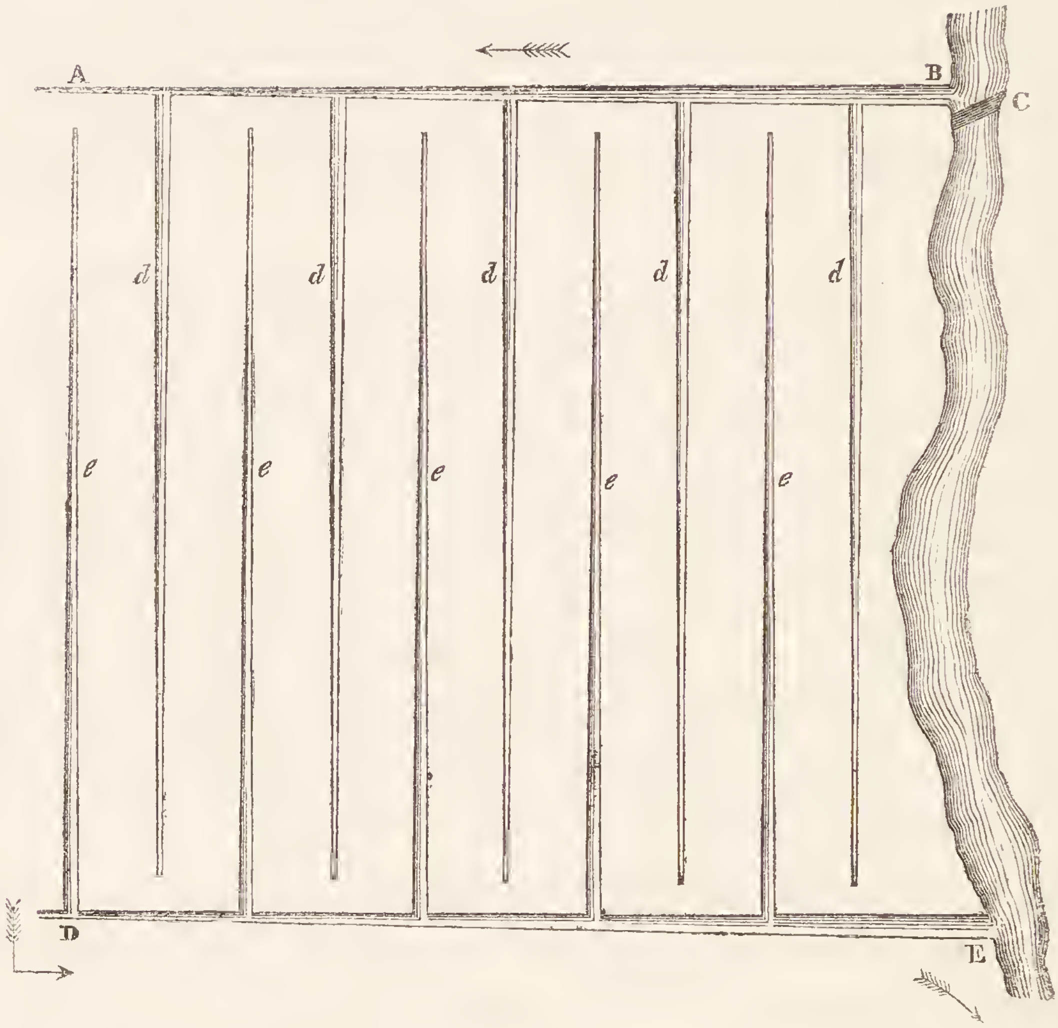
these cases the main purpose is the same, namely, to supply the deficiency of water in the soil ; and this creates a great distinction between that species of irrigation which has been described as called for by the wants of man over so great a part of the globe, and that to which we apply in England the term watered meadow.

In the latter case, the purpose is not to supply the deficiency of water to the soil, for the water is conveyed over the surface at those times, namely, the months of winter, when there is an excess, and not a deficiency, of moisture. Nay, it is held necessary in every well-formed watered meadow, to drain the ground very thoroughly of subterraneous water. Nor is this the only distinction between the two kinds of irrigation. In the one, the water is generally allowed to stagnate until it shall have saturated the soil; in the other, it is never allowed to stagnate, but is maintained in a constant flow over the surface.

In one respect the two kinds of irrigation may serve a common purpose, that is, by the deposition of mud or other fertilizing matter upon the surface. The principal effect, we may believe, which the Nile produces in its periodical overflowings, is the supplying to the soil of the mere element of water, without which, an arid soil, in a country where rain is scarcely known, would hardly produce any thing. But this effect is plainly greatly increased by the large quantity of mud which the river deposits. In the case, too, of the watered meadow, the water may, in like manner, deposit a fertilizing sediment ; but this, though it always adds greatly to the effect, is not essential to the producing of it ; and waters entirely free from all perceptible sediment, are yet successfully employed in the case of the watered meadow.

In the watered meadow, a stream of water is to be conducted to the surface, and caused to flow over it in a constant manner ; the meadow to be watered, for the most part lying upon the bank of the river from which the water is conveyed, and forming a flat surface, or rather a gently inclined plane. To the highest part of this inclined surface the water is conveyed in what is termed the main conductor, either by building a wear or dam across the

Fig. 194.



river where the water is to be taken off, or by bringing it from a higher source. In the preceding diagram, B A represents the main conductor, and C the wear or dam.

From the main conductor, and as nearly as possible at right angles to it, are taken off the various feeders, *d d d d d*. These consist of small trenches 4 or 5 inches in depth, made widest, as a foot or 16 inches, where they issue from the main conductor, and gradually lessening as they recede from it. They may be formed at the distance from one another of 40 feet, or less, being nearer where the soil is stiff and retentive, and farther distant where it is loose and porous.

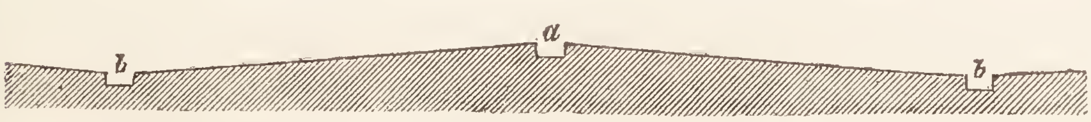
The water is thus conveyed to the surface of the meadow. But it is necessary that it should maintain an equal flow over the ground, and so be carried off as quickly as it is admitted. This is done by means of the main drain D E, formed at the lower part of the meadow, and the several smaller drains, *e e e e e*, passing

between the intervals of the feeders, in the manner shown in the figure. These small drains are of the same dimensions as the feeders, but are larger where they enter the main drain, and become gradually smaller as they recede from it. The main drain conveys the water back to the river from which it was taken.

But often this main drain becomes in its turn the main conductor to another meadow on a lower level. For the water which had floated the upper meadow being collected in this drain, can be carried from it by means of feeders in the manner described, and again collected in a drain below: and in this manner various meadows may be successively floated by means of the same water. And even where the lower meadows are nearly on the same level as the higher, it is still expedient to resort to this repeated collection of the water in drains, for it is found in practice difficult to preserve the equal flow of the fluid over a very large extent of ground.

In order to keep the water as it descends through the feeders at the necessary level, and to cause it to overflow the surface, it is interrupted in its course by what are termed stops, placed in the feeders. These sometimes may consist of small pieces of plank, each resting on two little stakes; but oftener they are merely sods placed in the feeders, which are sometimes fixed down by wooden pins. It is the province of the person who superintends the meadows, when floated, to adjust these stops in such a way as to maintain an equal current over the ground. Further, in order to convey the water quickly from the feeders to the drains, the surface of the meadow is formed into low ridges, the feeder being on the top of the ridge, and the drain in the hollow, a transverse section of which would appear thus:—

Fig. 195.

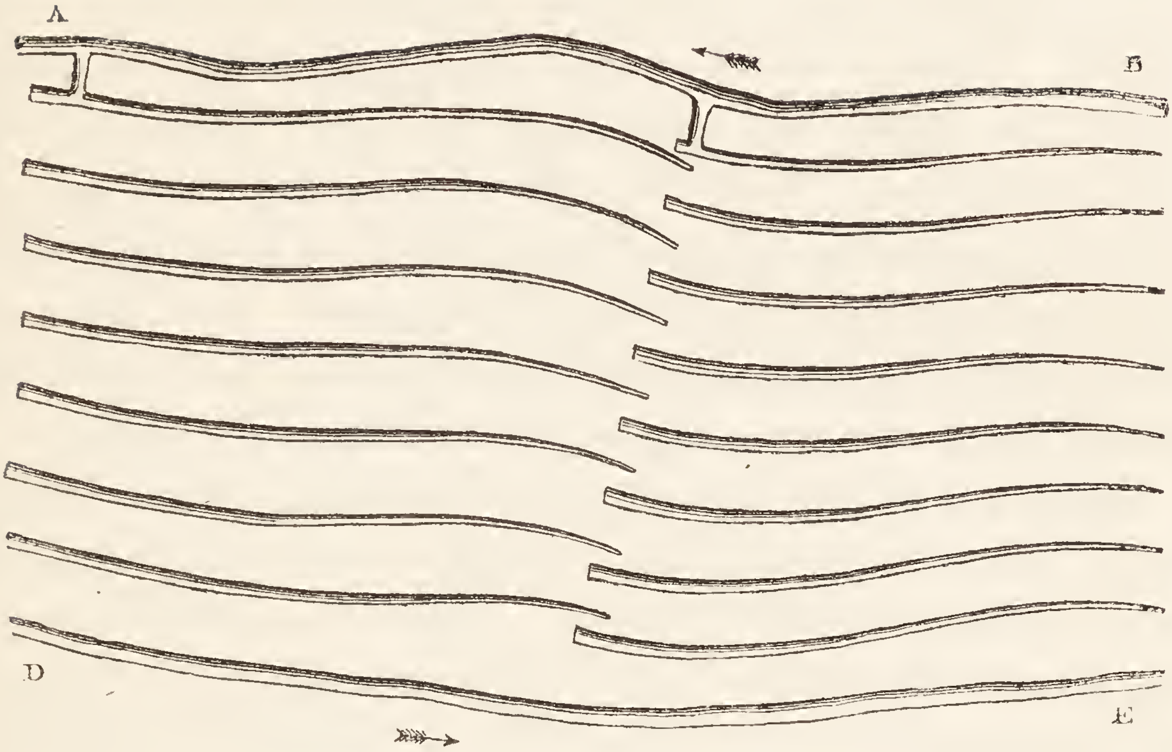


Here *a* represents the feeder, and *b b* the drains; and in the language of the irrigator, the interval from *a* to *b* is termed a pane.

This is the most perfect form of the watered meadow. But when the inclination of the plane of the surface is considerable, a different principle must be adopted for the conveyance and distribution of the water. In this case, the feeders are not carried longitudinally through the meadow, but across the line of the descent, in the manner shown in Fig. 196. Here the several feeders are filled as before from the main conductor AB; but the water having overflowed the lower side of the banks, is not discharged into smaller drains, as in the former case, but into the next feeder lower down; and is thus conveyed from feeder to feeder, over the entire space of the meadow, to the main drain DE. This species of irrigation is termed catch-work, and, as it can be adopted where the surface is too much inclined to admit of the flat meadow, it is frequently practicable where the other is not, and is often combined with it in the same meadow where there are inequalities of surface.

The process of floating the meadow commences generally in the month of October, being as soon as possible after the aftermath has been consumed, or the last crop of hay removed. The water is kept upon the ground for periods of a fortnight or three weeks at a time. It is then let off, and the ground laid perfectly dry for five or six days; and this process of alternate flooding and drying is continued generally during the months of November, December, and January, care being taken to let off the water when it begins to freeze. As the spring advances, and the grasses shoot forth, the periods of watering are shortened, so that the flooding shall not last above five or six days at a time. In the southern counties of England, the meadows are ready for the reception of stock of all kinds in the middle of March; but more to the north, where the grasses do not make such early progress, the flooding is generally continued during the whole month of May. After this, it is discontinued for the season, and one or more crops of hay are produced. Flooding during the months of summer produces a rapid and rich vege-

Fig. 196.



tation. But it is by summer flooding, where it is practised, that the fatal disease of rot is introduced, so that no sheep should ever touch the meadows which have been flooded during the summer months.

The theory of the process of irrigation has been variously explained. That the effect is not produced by the mere supply of deficient water, appears not only from the period at which the water is admitted, and when in our climate the soil is always saturated with the fluid; but from the circumstance, that the effect is not produced when the water is allowed to stagnate, and sink down in the soil, but when it is kept in a current over it. When the water is suffered to stagnate, the soil tends to produce carices, junci, and other subaquatic plants; but when it is kept in motion, and drained off at intervals, the finest grasses peculiar to the soil and climate are produced. Neither does the fact of the deposition of mud, or other fertilizing sediment, explain the phenomenon; for however such depositions may increase the effect, it is likewise found that water, without any perceptible sediment, may be employed with success. It has been supposed, that the water acts beneficially, by maintaining the soil at a higher temperature. Water at a temperature of 40° is of a greater specific

gravity than at a lower temperature; and hence, as the water tends to the freezing point, the warmer portion of it is next to the ground. Much, however, cannot be ascribed to this cause in a current so shallow and constant as that which passes over the watered meadow. It may be believed, therefore, that the main effect is produced by the water acting upon and bringing nourishment to the fibres of the roots of the plants. The water contains a quantity of atmospheric air and carbonic acid, and always certain earthy and saline matters in suspension and solution.

England is perhaps the country in which the watered meadow, as the mean of producing hay or herbage, is the best understood, and the most extensively pursued. There is no reason to doubt that this art, like so many others, was derived from the Romans; and circumstances have conduced to its extension in England even more than in Italy.

England is well suited to the production of the common grasses. These grow with a closeness and variety in the species unknown in more southerly countries, and with a vigour which ceases in higher latitudes. The rivers, too, in England, particularly in those parts most distinguished for this branch of husbandry, are generally turbid, and flowing through a fertile and cultivated country, are enriched by the animal and vegetable matters which they receive in their progress, and thus not only irrigate, but manure, the lands to which they are conveyed. The counties of Gloucester and Wilts have long been the most celebrated for their irrigation; but there are now others perhaps not inferior to them in the extent and perfection to which the practice has been carried. In the north of England, the practice almost ceases; and on the Scottish side of the Tweed, it is still less practised as a branch of the rural art.

The causes that have prevented this extension of the practice of irrigation to the north of England and to Scotland, are to be sought for rather in circumstances peculiar to those parts of the island, than in any indisposition on the part of the agriculturists there to adopt beneficial improvements. The useful effects of irrigation decrease with the diminished temperature of the cli-

mate. The rivers in the north generally flow through a smaller tract of cultivated country, and thus do not in the same degree receive those enriching substances which aid the purpose of irrigation; neither do their banks generally present those extensive flat plains so favourable to the art in the chief irrigating counties of England. But, hardly less than even the effects of climate and natural causes, a circumstance exists which retards the progress, and lessens the comparative importance, of irrigation in the northern parts of the kingdom: this is the general establishment of the alternate system of agriculture, and the economical means thereby afforded of producing hay by means of the clovers and cultivated grasses. The more costly system of tillage adopted in the greater part of England gives a higher relative value to land kept permanently in grass, and to the hay of the indigenous grasses, than in districts where a rotation of crops and cultivated herbage is extensively practised.

Although, for these reasons, the same value will never be attached to the watered meadow in the cultivated parts of Scotland, as in such counties of England as Wilts and Gloucester, it is to be desired that the art of irrigation were better understood in Scotland than it now is. Even in the best cultivated districts, there will always be pieces of land which may be advantageously used for the raising of hay as an addition to the provender of cultivated farms; and in the mountainous districts, forming the greater part of the whole country, where tillage on any considerable scale is difficult, inexpedient, or impracticable, the raising of hay for the support of live-stock, during the severities of winter, is an object of primary importance; and, in this respect, the resources of the watered meadow may frequently be made available with the best results. The effect of water, applied on the principle of the artificial meadow, is in all cases admirable, with regard to the production of indigenous grasses. Its effect is speedily to eradicate heath, and those mosses or lichens which infest the surface, and repress the growth of the nutritive plants; and, in all our mountainous districts, there is abundance of flat low land, barren, or productive only of the worst herbage in its

natural state, which admits of irrigation from the innumerable rivers and streams by which such districts are traversed.

The formation of the surface of a watered meadow is a work demanding practical skill ; and no one should think of attempting such a work, but under the direction of persons possessed of the required experience. The diagrams which have been given above illustrate the principle, but they do not in any degree exhibit the numerous variations that are required to suit the inequalities of the surface, the varying supplies of water, and other diversities of circumstances and situation.

Besides the watered meadow, properly so called, there is a species of irrigation which deserves the greatest attention where local circumstances are favourable to it. This is when the liquid refuse of towns can be conveyed in drains or sewers to the land. This may be termed a species of liquid manuring rather than irrigating ; yet it is found that the principles of the watered meadow, with respect to the mode of distributing and carrying off the water, are as applicable here as when the water is free from perceptible sediment.

Another species of irrigating is termed Warping. But the end of warping is merely the deposition of mud from turbid water, and it is therefore conducted on principles entirely different from those adopted in the case of the watered meadow. It is usually the water of the tide in flat rivers that is employed for the purpose of warping. This is admitted by sluices, and having deposited the earthy matter which it contains, it is allowed to escape. In this manner, by repeated depositions, a large quantity of earthy matter is left behind, and a new soil by degrees formed. On the estuary of the Humber, where this operation is carried on on the largest scale, the water, rendered turbid by the meeting of the tides and the fresh-water, is conducted for miles inland, and, in the course of a single season, about a foot of the richest soil is added to the former surface.

X. THE REARING AND FEEDING OF ANIMALS.

I. THE HORSE.

1. Species and Varieties.

In the genus *Equus,* naturalists comprehend several species, or animals nearly allied; of which two are the subject of domestication, namely—

1. Equus Caballus—The Horse,
2. Equus Asinus—The Ass,

and the Mule, a hybrid produced by the union of these species.

The Ass has been the servant of man from the earliest records of the human race. He has come to us from the South and East, and it is there that he is seen in his perfect state. Were we to judge of the value and importance of this creature from the feeble services he is able to render us in the oppressed and degraded condition in which he appears in this country, we should form a very false estimate of his importance. He is the inhabitant of the desert, and an invaluable servant in the burning regions in which Nature has fitted him to exist. But yet more than this, he is endowed with the power of propagating a race of creatures of the highest importance to the inhabitants of many countries. The Mule, as an animal of burden in a rocky and precipitous country, far exceeds the horse or any other animal; and countries would remain separated from one another by impassable barriers, were it not for the matchless sagacity, patience, and surefootedness of this creature.

It is in the south of Europe, and in an especial manner in the mountainous parts of it, that the mule is to be regarded as important in the rural economy of Europe. Yet he is capable of being cultivated in the colder countries. He possesses the hardy properties which fit him for innumerable kinds of lighter labour;

he is long-lived, and remarkably exempt from diseases, especially of the limbs; and he can be maintained on far inferior kind of food to that required by the horse. The difficulty which presents itself to the rearing of him to the same perfection in the colder parts of Europe as in the warmer, is that the male parent, the Ass, cannot be brought to perfection in cold countries; and when the stallion is employed, the progeny, termed a Hinny, is never equal to the true mule.

It is the Horse, then, which especially interests us in this country as the subject of cultivation. The horse, although he will partake of animal food, is strictly herbivorous, and more scrupulous with respect to the food he consumes than the ox. His stomach is comparatively small, and he eats often. He sleeps little, and frequently standing, for which purpose Nature has made a peculiar provision in the form of his limbs. In sleeping he is startled by the slightest motion.

The horse is vastly modified in his form and characters by the physical condition of the countries in which he is naturalized. If reared in a country of plains and rich herbage, he tends to become large in his form; and such is the character of the horse of the plains of Northern Europe, as of Holstein, England, and other countries abounding in rich herbage. But in an elevated country, where the herbage is scanty, the size and form of the horse vary with the circumstances in which he is placed. There he becomes small, hardy, and capable of subsisting on the scanty herbage with which the mountains supply him. No contrast between animals of the same species can be greater than that between the horse of the mountains and the horse of the plains. The pony of Norway or the Highlands of Scotland, as contrasted with the huge horse of the Lincolnshire fens, presents such extremes of strength and size, that it is difficult to believe that creatures so different can be of the same species. Yet all this great diversity is ascribed to a difference in the supplies of food, as influenced by the effects of situation. Nor is this peculiar to the horse; the domestic ox and the sheep are subject to the same law, and in a no less remarkable degree. These animals are es-

sential to the subsistence of the human race, and, by a beneficent provision of Nature, they are formed to adapt themselves to the circumstances in which they are placed.

The horse fed on the arid plains and scanty herbage of warmer countries assumes characters and a form entirely distinct from those of the large and massive animals fed on the rich pastures of temperate countries. It is from this cause that the large horse of England and the northern plains of Europe contrasts in a striking manner with the lighter horse of other regions. As we pass from the northern to the southern parts of Europe, this change of form and character appears, but yet more when we have crossed into Africa. There the horse of the desert displays the light form and agile shape which fit him for his condition. We see that he is here the creature of the circumstances in which he is placed. The heavy horse of the plains of Germany and England could no more subsist on the dry and scanty herbage of Libya than on the heaths of Norway. The species would perish in conditions so different did not Nature provide a remedy, by adapting the animal to its condition.

The ancient horses of the North of Europe must have consisted either of the smaller horses of the mountains or of the larger horses of the plains. The horse which was chiefly employed for common uses, for war, for the tournament, and even for the chase, seems to have been of the latter kind. This appears from the accounts and representations given of him, and from the form which he yet retains when unmixed with the blood of the lighter races of the South and East. It is to this intermixture that the technical term *blood* is applied. Importations long ago took place of horses from Spain, from Barbary, and the Levant, and, at a later period, from Arabia. The African and Arabian horses, accordingly, have given their characters to the blood-horse of England and its innumerable varieties.

The animal in which this effect of blood is the most remarkable is the English race-horse. For the combination of speed with the necessary strength, this creature can scarcely be surpassed. He forms, however, a race of artificial creation, admir-

ably suited for a particular purpose, but deserving of cultivation, from this, that it is the stallions of this race which are employed to communicate the properties of lightness and power of speed to the inferior races.

From the race-horse, downwards to the races where no mixture of southern blood can be traced, the gradations are innumerable. It is in this class that our hunters, our road-horses, and hackneys, the horses employed in our coaches and carriages of all kinds, nay, often in the mere labour of heavy draught, are contained. It forms the most numerous class of horses in the country. But many of them are bad, having lost the hardiness and strength of the native race, without having arrived at the speed and other qualities of good breeding. They can scarcely be reduced to breeds, but may be conveniently classified according to the uses to which they are chiefly applied.

The superior class of riding-horses, generally termed the hunter, is perhaps the finest race of horses known. It combines the blood of the Arabian, and other races of the South and East, with the powerful form of the horse of the north of Europe, in a happier proportion than even the race-horse.

There is a class of horses also, which, from their numbers and similarity of characters, have been usually regarded as a true breed. These are the Cleveland Bays, reared chiefly in the district of Cleveland in Yorkshire. They are designed for coaches, chariots, and the lighter equipages. These are a very beautiful class of strong and agile horses, in high request in this and other countries.

The remaining classes of horses consist of those in which no mixture, or a very slight one, of stranger blood is found. These are either the ponies of our mountains and commons, or the larger horses of the plains. It is the last that interest the farmer as the animals of labour, and to them we commonly apply the term *cart-horse* or *farm-horse.*

The variations produced in these horses by different effects of food and management are very great. But sometimes classes of them exist in sufficient numbers, and with characters sufficiently

permanent, to allow the term *breeds* to be applied to them. The most commonly enumerated of these breeds are—

1. The Old English Black Horse.
2. The Suffolk Punch.
3. The Clydesdale Horse.

The Old English Black Horse may be said to be the native horse of the richer plains of England. He is chiefly bred in the midland counties from Lincolnshire to Staffordshire. These horses are of large size, with the breast broad, the thighs and fore-arm large and muscular, and the legs somewhat short. It is this variety which supplies London with those enormous dray-horses which excite the wonder of strangers. The defect of this breed is the too great bulk of the individuals, their consequent slowness of motion, and their comparative want of action. These faults, however, may be corrected, and have been so very generally; and the true black horse of England affords the materials of an excellent breed.

Northward from the Humber, the horses of draught become less heavy, and more varied in colour and form. Many admirable horses of this mixed class are reared in the counties of York, Durham, and Northumberland.

The Suffolk Punch is so termed from its round or punchy form. This breed is supposed to have been produced by a mixture with the horses of Normandy, which, from the similarity of characters, is probable. The Suffolk Punch is usually of plain figure, but compact, useful, and of good action. This breed is in great request in the counties of Suffolk, Norfolk, and Essex, where it is preferred to every other for the plough. The Suffolk Punches have been long remarked for the trueness with which they perform their work, and in an especial degree for their steady exertion at a dead pull. The breed has been largely crossed by the horses of Yorkshire and Durham.

The Clydesdale is the breed of the western plains of Scotland, though cultivated in elevated districts. The horses of this breed are less than the heavy black horses of the midland counties; and

they draw steadily, and are generally free from vice. They are reared by the farmers of the district, and have good justice done to them with respect to feeding and light work, while in the hands of the breeders. It is to the good treatment of them when young that these horses owe much of their usefulness. Although inferior in physical strength to the English Black Horse, and in figure to many of the better class of draught-horses of Yorkshire and Durham, these horses have properties which render them one of the most safe and useful class of farm-horses to be anywhere found.

Full descriptions of these and the other races and classes of horses proper to, or naturalized in, Great Britain, are contained in my Works on the Domesticated Animals of the British Islands.*

2. Form.

An examination of the form of the horse requires a cursory one of his anatomical structure.

The bones of an animal constitute, it may be said, the foundation on which is erected the edifice of the living machine. They mainly give to it its form and proportions. Their various parts, connected by flexible ligaments, are capable of all the varieties of motion fitted to the condition of the animal.

Motion is given to the bones by means of muscles or fleshy fibre; but the flesh of animals is not a mere stratum covering the bones. Every muscle is a distinct organ, consisting of innumerable parallel fibres, forming as it were, a fleshy band, stretching from bone to bone, or from muscle to muscle, and each serving its peculiar function.

These muscles are of vast power when under the influence of

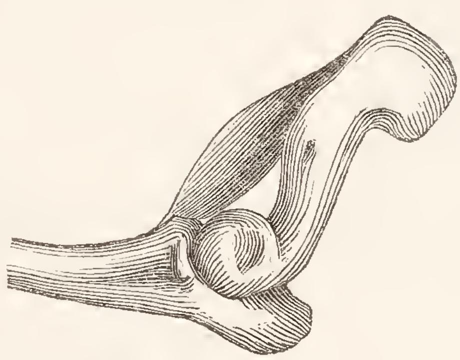
* 1. On the Domesticated Animals of the British Islands, comprehending the Natural and Economical History of Species and Varieties, the Description of the Properties of External Form, and Observations on the Principles and Practice of Breeding. 8vo. 21s.

2. Breeds of the Domesticated Animals of the British Islands, with illustrative coloured lithographic plates, 2 vols.

the vital principle. By contracting, they give motion to the bones and other parts. Each muscle consists of long threads or fibres, seemingly bound together by mesh-work. These fibres, in so far as the eye, assisted by very powerful glasses, can discover, are resolvable into minuter filaments. A number of these filaments may be said to form a fibre or thread; a number of these fibres to form a fasciculus or bundle of fibres; and a number of fasciculi to form a muscle.

Muscles assume a variety of form suited to their peculiar functions. Sometimes they are flat, extending over a considerable space, and often they form a fleshy band, swelling out in the centre,

Fig. 197.



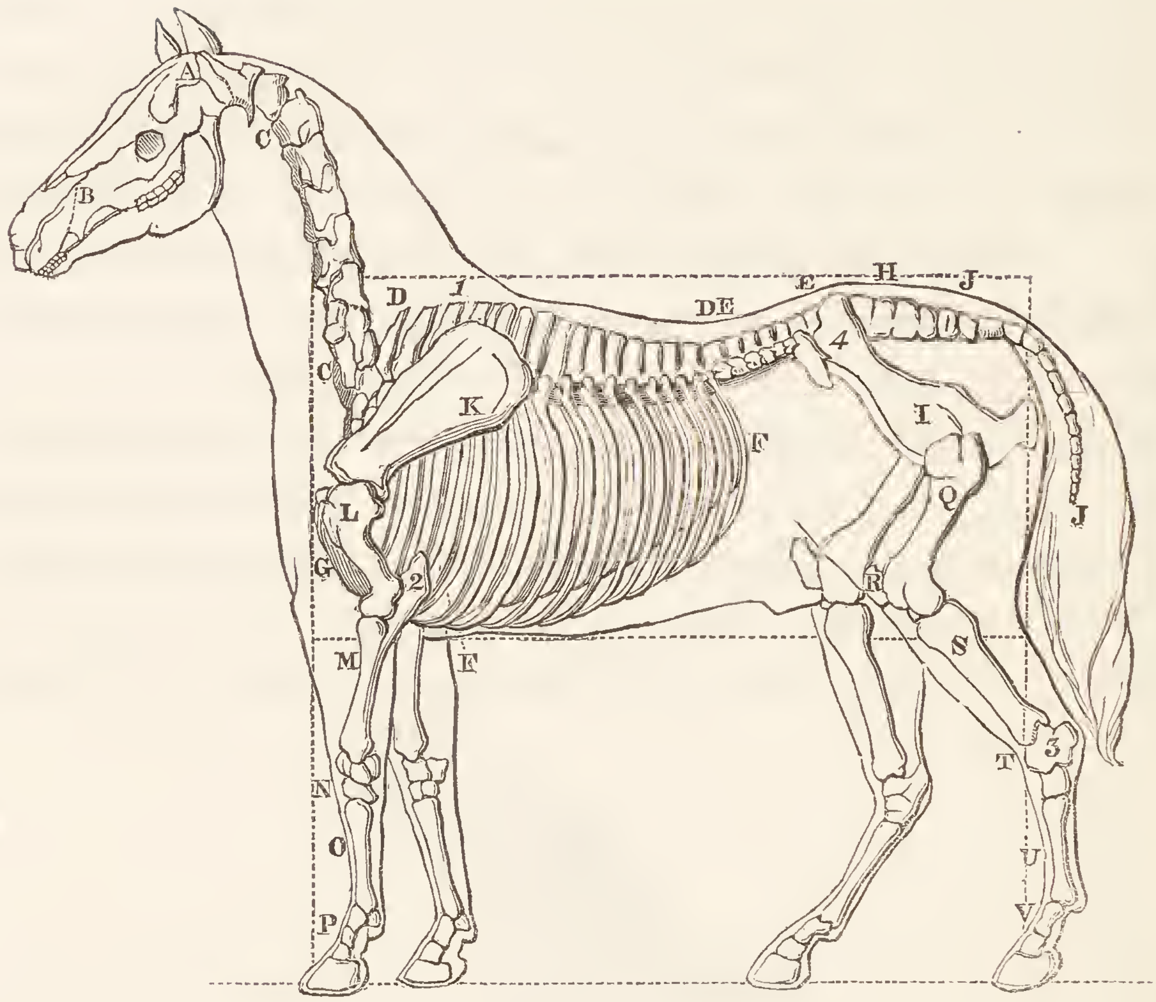
and becoming small and tendinous at the points of their attachment to the bones.

Not only is a class of muscles employed in giving motion to the bones, but a numerous class is employed within the body in giving motion to the organs of circulation and nutrition, as the heart and the stomach. The number of muscles is wonderfully small when we consider their functions, and the infinite variety of motion in the animal; for, from the motions of the limbs to the expression of the face and modulations of the voice, all is moved by this machinery of surpassing beauty and simplicity.

The bones, although harder than the muscular structure, are, like it, the parts of a living machine, furnished with their blood-vessels and nerves. They give to the animal its peculiar form, and, acted upon by the muscles, its powers of progression.

The following figure represents the connexion of the principal bones of the horse:—

Fig. 198.



CC Cervical vertebræ.
DD Dorsal vertebræ.
EE Lumbar vertebræ.
A Bones of the cranium.
B Bones of the face.
H Sacrum, or rump-bone.
JJ Bones of the tail.
FF Ribs.
G Sternum, or breast-bone.
I Os innominatum.
Q Os Femoris, thigh-bone or haunch-bone.
S Bones of the leg.
R Patella, or stifle-bone.
T Tarsal bones, or bones of the hock.
U Metatarsal bones of the hind-leg.
V Phalangeal bones, or bones of the fetlock and foot.
K Scapula, or shoulder-blade.
L Humerus.
M Fore-arm.
N Carpal bones.
O Metacarpal bones of the foreleg.
P Phalangeal bones.
1. Withers.
2. The elbow.
3. Point of the hock.
4. Hip-bone.

The series of bones to which the others may be regarded as attached, is the vertebral or spinal column. This, in man, is erect, forming what is termed the back-bone. It is a pillar of bones, flexible, and of great strength, serving to support the head. These bones or vertebræ are jointed or articulated together, with

a certain power of motion, and firmly bound by strong cartilage. Each vertebra has a cavity passing through its centre, so that, when all are united together, there is a continued canal passing along the whole column. It is within this canal that the continuation of the medullary part of the brain, or spinal chord, is enclosed. Radiating from this, and passing through holes in the column, are nerves destined to give sensation to the muscles and other organs.

In man the number of vertebræ is 24, in the horse 30; in man the column is erect, in the horse it is horizontal, to suit the position of a quadruped.

Of the vertebræ, those peculiar to the neck are termed cervical; those belonging to the back, and from which the ribs arise, dorsal; those belonging to the loins, lumbar. In man there are 7 cervical, 12 dorsal, and 5 lumbar, vertebræ; in the horse there are 7 cervical, 18 dorsal, and 5 lumbar, vertebræ.

These vertebræ have each projections termed processes, which are designed for the attachment of muscles, and of which the upright are termed spinous processes. In the horse, the spinous processes next the neck are very large, forming what are called *withers*. To them are attached muscles and ligaments which support and give motion to the head and neck; and large withers are connected with the power of active motion in the horse.

Jointed or articulated to the first of the cervical vertebræ is the head, containing the brain and the principal organs of sense. The bones of the head are divided into two classes, those of the cranium or skull, and those of the face. The bones of the cranium are distinct pieces, firmly united, and many of them dovetailed into one another, and forming a cavity fitted in the happiest manner for the protection of the vital organ within. The manner in which the cranium is articulated to the upper vertebra, is analogous to that in which the vertebræ themselves are united together. The cranium may be said to be itself a series of vertebræ, its parts being merely expanded and enlarged, so as to form a cavity for containing the brain.

In man the cranium and face are round: in the horse they are

elongated, in order that the mouth may collect food. The head in man is nicely poised upon the summit of a column: in the horse, in order that it may reach the ground, it is pendent. In the horse, its great weight is supported by powerful muscles, and by a strong ligament extending from the head to the spine. It is for the better attachment of this ligament and muscles, that the withers of the horse are large: in man withers are not required.

The prehensile organ of the horse being the mouth, and not as in man the hands, the length of the cervical vertebræ must be so much greater in the horse than in man, that he may be able to reach the ground and collect his food. Although the number of cervical vertebræ in the horse is the same as in man, their relative length in the horse is much greater.

The spinal column becomes larger towards the base, when it gradually diminishes. This portion of it forms what is termed the sacrum; the bones of which are not jointed, but united so as to form one bone. The vertebral canal is continued into the sacrum, and sends forth nerves to the lower extremities. In man the sacrum is terminated by four or five little bones united together; in the horse these bones extend to a greater length, forming the caudal vertebræ or tail.

Rising from the several dorsal vertebræ are the ribs. These bones are flat, bent, and elastic, and terminate in cartilage. In man the number of dorsal vertebræ, and consequently of ribs, is 12 on each side. In the horse the number of dorsal vertebræ, and the number of ribs, accordingly, on each side, is 18.

The other bones connected with the spinal column are those of the pelvis, to which is attached the bone of the thigh. Connected with the spinal column also by muscles, is the scapula or shoulder-blade, to which is attached the humerus or bone of the shoulder.

The pelvis is at the lower part of the spinal column in man, and at the hinder part in the horse. It is a large irregular-shaped cavity, formed by the ossa innominata and other bones. It is within this cavity that the fœtus is developed and nourished. A prominent bone of the pelvis is the ilium or hip-bone.

Into a cavity of the os innominatum on each side is inserted the os femoris or thigh-bone. The thigh in man is altogether detached from the trunk; in the horse, being enveloped in muscle, it forms apparently a part of it. This is required by the different position of the animal, and the bone has sufficient facility of motion in the manner in which it is placed. In man it stands vertical; in the horse it is bent, which prevents the animal from being raised too high above the ground. In this position, too, he has a greater power of progression. When he moves the limb backwards it describes a large arch of a circle. Now, were the thigh placed perpendicular to the ground, it will appear from the figure, that, when stretched backwards, it would describe a smaller arch of a circle. Its length, therefore, combined with its bent position, conduces to the vast power of progression of the animal: and the comparative power of motion in horses is very much dependent upon the length of this part. This greater length of the thigh-bone, again, is indicated to the eye by the distance from the hip-bone backwards, forming what are termed the hind-quarters. Jockeys, accordingly, always look to the size of the quarters as connected with the power of rapid progression of the horse.

Next in order are the bones of the leg, consisting, first, of the patella or stifle-bone, corresponding with the pan of the knee in man, and next of the two bones, the tibia and fibula, united in the horse, and forming the leg properly so called, and corresponding with the leg in man. The leg of the horse should be long in proportion to the lower parts of the limb.

The further bones of the limb correspond with the bones of the heel, the foot, and the toes of man. The bones of the heel in man are termed the tarsal bones; of the foot, the metatarsal bones; and of the toes, the phalangeal bones. In man the tarsal bones are in number 7, the metatarsal 5, and the phalangeal 14. In the horse, the bones corresponding to the tarsal, metatarsal, and phalangeal bones, are likewise, as in man, many; and this number of bones adds to the flexibility and elasticity of the limb.

Man, however, standing erect, requires a large pediment of support. The bones of the foot, therefore, are made to rest upon the ground. But the horse, having four limbs of support, does not require this large pediment. The metatarsal bones of the horse are therefore extended, in order to give length to the limb. The phalangeal bones form the fetlock and other parts, giving to them flexibility and elasticity; and the lowermost only of the phalangeal bones are brought into contact with the ground. These last are not separate as in man, but together, and defended by horn. The horse, therefore, may be said to stand on his toes; and if any person will attempt to walk on all-fours, he will find that the toes will touch the ground, while the bones of the foot will be raised up.

The bone of the horse termed the point of the hock, corresponds with the great bone of the heel in man. To this are attached powerful muscles; and the size of this bone, therefore, as giving space for the attachment of muscles, is connected with the power of progression in the horse, and is therefore one of the points looked at by jockeys.

The bones of the other extremity of the horse correspond with the arm, the fore-arm, the wrist, the hand, and the fingers in man. In man the hand forms the prehensile organ, and a great flexibility is given to the different bones which form it. In the horse these bones form the limbs of support. They are not designed to seize objects, but to support the weight of the animal before,—to be raised from the ground when he pushes himself forward by the extension of the limbs behind,—and to receive his weight when he again reaches the ground.

The scapula or shoulder-blade is in the horse, as in man, a large flat triangular bone, placed upon the ribs, and connected by means of muscles with the head, the ribs, and the spine. In man, the two scapulæ are kept from approaching one another by the clavicle or collar-bone. From the form and position of the horse, this approximation cannot take place; and there is therefore no collar-bone in the horse.

Into a cavity of the scapula is jointed on each side the humerus.

But the humerus, or arm from the shoulder to the elbow, is in man detached as it were from the body ; while in the horse it seems to form a part of it ; and in this position it has sufficient power of motion. It is bent, as will be seen from the figure,—an admirable and necessary provision to lessen the shocks which the animal receives on bringing his limbs to the ground ; for by this flexure it acts the part of a spring. Were this bone vertical, the limb would be shattered when it struck the ground.

The shoulder of the horse should be oblique, and the humerus relatively short. The obliquity of the shoulder is a point connected with action in the horse; and the reason why the humerus should not be long, will appear from the function which it has to perform. When the animal moves the limb forward to raise it from the ground, the humerus has to describe an arch of a circle; but the muscular power being sufficient, the shorter radius describes an equal arch with a longer, and thus fulfils its function with less displacement of the parts than when the radius is long.

The next of the bones are two, the radius and ulna, united together in the horse, forming the fore-arm in man, and what is termed the fore-arm in the horse. The termination of the ulna, corresponding with the elbow, forms an important point of the horse, because to it are attached powerful muscles for the movement of the limb. Jockeys, accordingly, look with attention to the size of the elbow of the horse.

The remaining bones of the limb correspond with the bones of the wrist, the hand, and the fingers, in man, termed respectively the carpal, metacarpal, and phalangeal bones.

The carpal bones of the horse are commonly called the bones of the knee; but these bones do not correspond with the knee, but with the wrist of the human body. In man, they give flexibility to the hand ; in the horse they give flexibility to the limb of support.

The next bones are the metacarpal bones. These correspond with the bones of the hand in man ; but in man they form a part

of a prehensile organ; in the horse they are extended in order to give length to the limb.

The bones of the fetlock and foot correspond with the phalangeal bones, or bones of the finger in man. They are distinct in man; they are together in the horse, and, touching the ground at their extremities, are defended by horn.

The horse, abstracted from his neck, and viewed in profile, is contained nearly within a square, of which the body forms one-half, and the limbs form one-half. In this respect the form of the horse differs greatly from that of the ox, the body and limbs of the ox, abstracted from the neck, being included in a rectangle, in the manner to be afterwards shewn, and the body forming a greater proportion of the rectangle than the limbs. This circumstance would alone account for the greater power of progression of the horse than the ox.

In the horse, while sufficient space must be given in the size of the body to the respiratory and nutritive organs, this space must not be too great, because then the body will bear too large a proportion to the limbs for the purpose of active motion. In the ox, the larger the proportion of the fleshy matter of the body to the limbs the better.

In the case both of the horse and the ox, the large expanded chest indicates a disposition to fatten; but if this be carried too far in the horse, he will be incapable of active motion. Such a form may suit the dray-horse, when a large force is to be thrown upon the collar: but would be unsuited to those cases in which we require the power of active motion, or, in technical language, action.

In a horse where speed alone is required, the chest must not be too broad before; but in a horse in which we require active motion, combined with endurance, there should be a sufficient breadth of chest: and a medium, therefore, is what is desired in the hackney and the hunter. In the farm-horse, the chest should be broad; because in the farm-horse we require the power of draught, and not of speed.

The chest of the horse behind the shoulders should be deep;

his back, when we look for strength without sacrificing this to mere speed, should be short; the ribs should approach near to the pelvis, as indicating strength, though, if speed alone be required, this point may be sacrificed. The fore-arm and hind-leg, to the joints, should be muscular, and below these joints tendinous. The trunk should be barrel-shaped, but somewhat elliptical, and gently enlarging from the breast backwards.

3. Rearing and Feeding.

In the breeding of the horse, it is important that the parent of either sex be free from disease. It is well known to all breeders, that the diseases of the parents, as well as their good properties, are transferred to their offspring. In breeding, attention should be paid to the female as well as to the male parent, else disappointment may result with respect to the form and properties of the progeny.

A mare is capable of receiving the male at an early age; but it is an error to commence breeding from any mare before strength has been acquired, and her form developed; and this will rarely be sooner than at three or four years of age.

The mare comes into season in spring: she goes with young about eleven months, although with an irregularity, even to the extent of several weeks on either side of that period. The most convenient time for her receiving the male is in May, that she may foal in April, when the herbage begins to spring. From the time she receives the male to that of foaling, the farm-mare may be kept at her usual work. She will give notice of the period of foaling, by the extension of the udder, and other symptoms, and she may then be released from work.

In general, little difficulty or danger attends the parturition of the mare. She rarely requires assistance; but, should difficulty really arise, from the particular position of the fœtus, it is proper to obtain the assistance of a veterinary surgeon, lest the mare be injured by unskilful and violent treatment.

As soon as the mare has foaled, she should be placed with her young, either in a house, or, what is better, in a pasture-close or paddock, with a shed to which she may go at all times. It is necessary, at this period, to supply her with nourishing food.

It is better that the mother be kept in a field, and permitted to suckle the young undisturbed. But yet she may be put, without danger or injury, to moderate work within a short time after foaling.

In this case the foal should be shut up in a house during the hours of work, which then should not be too long; but, after the colt has acquired a little strength, it may be permitted to follow the mother even when at work in the fields. Many, indeed, do not approve of this practice, on account of the chance of accidents to the foal. But accidents seldom occur, and the foal has an opportunity of taking milk more frequently, is the better for the exercise, and becomes used to the objects around it. It is certainly better, however, that the mare be permitted to suckle her foal undisturbed; and no other course is to be thought of with the finer classes of horses.

In nine days or more after foaling, the mare will be again in season, and may receive the male. In six months the foal is to be weaned, which is done merely by separating it from the dam. It is then best put into a field. The mother is set to her ordinary work, and treated as usual.

At the time of weaning, and during all the period of its growth the foal should be liberally fed. Bruised oats, meal, or any farinaceous food, may be given to it. It is not necessary or proper that it be pampered; but it is important to its growth and vigour, that it be supplied with sufficient food.

The male foal intended for agricultural purposes must be castrated; and the best period for performing the operation is at the age of twelve months. Some do it before weaning, but it is better that it be delayed till the masculine form of the animal has been more developed.

If the colt be intended for the saddle, it is well that from this period it be accustomed to gentle handling by the person who feeds

it, for this is a mean of rendering it docile and good-tempered. But however this be, nothing but kindness is to be shewn to these young creatures, and any thing like rough treatment is to be carefully avoided.

The colts are kept in their pastures during the summer, and when these fail before winter, the animals may be put into a yard with sheds, and plentifully littered with straw, like the young oxen upon the farm. They may receive straw for half the winter, and hay towards spring when the straw becomes dry and unpalatable; but it is better that they receive hay alone; and turnips, or any green food, should also be supplied to them freely throughout the winter. It is a great error to starve colts, for this injures their growth and vigour in a degree far beyond the value of the increased food required. Although they may be confined in a yard in the manner described, it is greatly better, where convenience allows, that they have a piece of ground on which they may run in winter. This is favourable, in an eminent degree, to their health, and the state of their feet.

But, however the colts are managed in winter, as early in spring as the pastures will allow, they are to be turned out to graze in the fields, where they are to be kept during summer; and in the following winter put again into the yards or paddock, and treated in the same manner as before.

And they are to be treated in a similar manner in the following summer and winter; after which, namely, when three years old, they will be in a condition to be broken in, and, if draught-horses, employed in the work of the farm. They may be taken up for training even in the third autumn of their age, though at this period the work should be very gentle.

A farm-horse usually receives little training, though it is better that a partial training, as in the case of the horse intended for the saddle, be given. But whether this be done or not, the colt should have a bridle with an easy bit put upon him for ten days or more, and allowed to champ it for an hour or two at a time in the stall. The harness being then put upon him by degrees, he may be trained to the different labours required of him.

In general, the farm-horse, working with his fellows, is easily brought to be obedient.

But when a farm-horse is four or five years old before he is put to work, or if he is a stallion, or if he shews any vice, a little more care may be proper, and a partial training, as if he were intended for the saddle, given him. And if he is a valuable horse, and fit also for the saddle and the carriage, the more complete the training given to him the better.

The art of training the horse for the saddle is now well understood, and the rude and violent practices of former times are generally abandoned by all who have any competent knowledge of the subject. In every case, gentleness and kind treatment are to be strictly observed in the management of the colt. He is first to be taught his duties, and corrected afterwards only when necessary to enforce submission. Fear, in the training of the horse, is that feeling with which he is soon endued, that he is under the dominion of a more powerful agent, whose will he cannot resist. Implicit submission is to be enforced, gently in so far as instruction is concerned, but by calling into action the principle of fear, when this is required to produce obedience. Decision and firmness, with a resolution to be obeyed, after the horse has been fairly taught the duties that are required of him, are altogether distinct from violence and cruelty. Nothing is so destructive to the temper of a horse as useless coercion, and all the defects of temper, when they exist in the young horse, arise, in the great majority of cases, from injurious treatment. But we are here chiefly to consider the management of the horse as an animal of labour.

The farm-horse demands, neither in the training nor in the feeding, that nicety which is required in the case of the horse designed for rapid motion or irregular labour. He requires merely to be maintained in good order, never to be worked beyond his power, and never to be allowed to fall, in condition, below the work which he is to perform.

The stable for the farm-horse, as for every other, should be spacious and well ventilated. It is a great error to suppose

that horses require a close, warm stable, to preserve them in health. To keep them fully sheltered, and free from the action of any cold current, is all that is requisite. The horse is well suited to bear an equal temperature, but not sudden changes produced by artificial means. Farm-horses regularly worked have been known to be kept throughout the coldest winters in mere sheds, not only without injury, but with greater benefit to their health than if they had been too closely confined.

Next to ventilation in importance, is cleanliness of the stable. No filth should be suffered to accumulate, but every day the stable should be cleaned out, with the same attention for the farm as for the saddle horse. In the farm-horse stable, every ploughman should have a small fork, a curry-comb, a brush, a mane-comb, and a foot-picker. (Figs. 76, 85, 86, 87, 88.)

Light should be admitted into every stable, to a certain extent. But in the case of farm-horses, which are only in the stable during the hours of rest and feeding, less light is necessary than in the case of the saddle-horse, which passes a great part of his time within doors. The light required for the farm-horse stable is that which is sufficient to allow the workmen to perform their duties in the day-time. Sometimes there is a room adjoining the stable for holding the harness, but it is perfectly convenient and sufficient in practice to have the simple furniture of the farm-horse hung on pins in the wall behind each pair of horses.

The food of the horse in this country consists of herbage, or green forage, as clovers and sainfoin; of dried forage, as hay and straw; of various farinaceous substances, as oats, barley, pease, and beans; and of the succulent roots of plants, as the potato, the turnip, the carrot, the parsnep, and the beet. Of the grains given to the horse, the most generally employed in this country, and that which is regarded as well adapted to his strength and spirit, is the oat.

The oat is, for the most part, given to the horse without any preparation, though it is sometimes bruised, which is beneficial, by rendering it more easily masticated. It is usually given in portions at a time, familiarly known under the term feeds, the

measure of which, however, varies in different districts. A feed in some places consists of a gallon, being the eighth part of a bushel, and weighing, upon a medium, about $4\frac{1}{2}$ lb.

Two gallons in the day, or 9 lb., are considered to be good feeding when the horse is on dry food, and not on hard work; when on hard work, the quantity may be increased to 3 gallons, and when on light work and green food, it may be reduced to 1 gallon, and sometimes altogether withdrawn. But on an average, 2 gallons in the day, that is, about 90 bushels in the year, will be sufficient in every case for the working-horse of a farm. In practice, too, it is not the superior but the lighter oats, formerly described, that are given to the farm-horses; but in this case a larger quantity should be supplied.

Oats may be given to horses reduced to a state of meal, but this is only practised in the case of gruel given to a sick horse. To induce a horse to take gruel, it is put into a pail and placed beside him, so that when thirsty he may drink of it.

Meal is sometimes given with cold water to horses when travelling. This is a refreshing feed to a horse on a journey, and a safe one when the chill is just taken off the water; but it is chiefly employed in journeys when time is of importance, and it is, accordingly, rarely given in the case of the farm-horse, who should always have time given him to feed.

When oats are kept in a damp state, fungi grow upon them, and they acquire a musty smell and bad taste. They should never be given in this state to a horse, but should first be kiln-dried, so as to expel the moisture, and destroy the fungi.

Barley is more nutritious than oats, although, in the practice of this country, it is not so much approved of in feeding. But over all the Continent, barley is the most common food of the horse. If bruised and mixed with chopped straw or hay, it is an excellent provender. But the most common method of giving barley to horses in England is in what is termed a mash. The barley in this case is boiled in water, and the whole is then allowed to stand until it is sufficiently cool. The mash forms admirable food for a sick horse; it keeps the bowels open, and is nutritive, without being heating.

Wheat is rarely used for the feeding of the horse, the proper destination of wheat being the food of man. The only case, in general, in which wheat, with a regard to economy, can be applied to the feeding of the horse, is in that of light wheat, which, being made into a mash, may be given to a sick horse in the same manner as barley.

Beans form an esteemed food for the horse. They are generally supposed to be more astringent than oats, and to correct the tendency to laxativeness when it exists. They should in all cases be bruised, and mixed with other farinaceous food.

The pea is similar in its feeding properties to the bean, and is even supposed to be more nutritive. It is, however, a dangerous food to be given in too great a quantity, from its tendency to swell in the stomach. It may, like the bean, be bruised, and should be given along with other food.

The details in the manner of feeding the farm-horse necessarily differ according to the practices of different districts. The following is a system, simple, efficient, and capable of being reduced to practice upon every farm:—

When the pastures, or other green food, fail in autumn, which will generally be by the beginning of October, the horses are to be put on hard food. They should receive at this period an allowance of hay at the rate of 20 lb. in the day, with 2 gallons of oats; or, in place of a portion of the oats, they may receive at night a feed of steamed food, consisting of potatoes, or any other roots, mixed with a little corn, and seasoned with salt. The whole quantity may be a peck, weighing about 12 lb. The quantity of potatoes that corresponds in nourishment with oats, is in the proportion of about 15 lb. of raw potatoes to 1 gallon of oats.

In the months of November, December, and January, when the days and the time of labour are short, the hay may be withdrawn, and the horses, in place of it, fed on straw, of which the best, when it can be obtained, is that of beans or pease. Next to these in quality is that of oats. The straw of wheat and barley is in this country only used as litter, though, were it to be cut into chaff, it could be advantageously used as fodder.

At this time the horses should receive 2 gallons of oats in the day; or the quantity of oats may be diminished, and a portion of steamed food given at night. They should receive, as before, two feeds, one in the morning before going to work, and one at mid-day, and their steamed food at night. By the beginning of February, they should again be put on hay, in preparation for their harder work in spring. At or before the time of sowing the oats, that being the commencement of the season of active labour, the horses should receive their full allowance of 3 gallons of oats in the day, or, in place of a portion of their dry oats, a corresponding allowance of steamed food. They should be fed three times in the day, a feed of oats being given in the morning, a feed at mid-day between the intervals of work, and at night they may either receive their third feed of dry oats, or a corresponding quantity of boiled food.

They are to receive this full allowance of hay and corn until about the beginning of June, when they may receive green food, on which they are fed during the remainder of the season, their daily allowance of oats being reduced to 1 gallon.

Three methods of feeding them on green food may be adopted :—they may be turned out to pasture in the fields ; they may be fed in the intervals of work on green food, and turned out in the evening to the fields to pasture; or they may have green forage cut and brought home to them in the yards or stalls.

When the first of these methods is adopted, that is, when the horses are simply pastured, they are merely turned out to the field at night after work; they are caught again, or driven home to the stables in the morning, and then again turned out after the morning's work, which may be about 10 o'clock, and allowed to feed till the afternoon's work, which may begin about 1 o'clock; they are then caught, and again set to work.

The defects of this mode of management are apparent. Time is lost in taking the animals to and from the field during the intervals of work; and then, having to gather their own food, they have too short a time for rest and feeding during the interval.

The second practice mentioned is to turn the horses out to pasture at night after work, but in the interval in the middle of the day, to give them cut green forage, which is brought home, and given to them in the stall or stable. In this manner they feed at leisure, undisturbed by insects; and, having their food collected to them, waste no time in gathering it in those hours which are suffered to elapse between the labour of the morning and that of the afternoon. This is an approved method of managing the horses of the farm. Their health is generally the better for their being kept out at night, while the advantage of this is combined with the economical practice of soiling.

The other method of feeding is to keep the horses constantly in the stable, or in a yard with sheds, and to feed them entirely on green forage. There is economy with respect to feeding in this system, and it is found to be perfectly suited to the habits and condition of the farm-horse. To carry on a system of soiling where clover and ryegrass are the forage-plants employed, a quantity of tares, equal to $\frac{1}{4}$ acre for each horse, should be sown, to be given to the horses in the intervals between the first and second cutting of clover, or when they are engaged at hard work in harvest, or at other times.

In the northern parts of this country, farmers cannot generally begin to cut clover till the 1st of June; but in the southern part of the country, the soiling can be commenced much earlier. When there are many horses, one man may be employed to do the work of cutting and putting the cut forage in bunches, and it should be taken home by a spare horse, so as to be ready when the horses return from work. One man will put into bunches a quantity sufficient for twenty horses, and each horse will consume upon an average about 200 lb. in a day.

When the horses are turned out to the fields at night, and kept on cut forage during the day, they should be put into their stables by the beginning of September, and kept in the house during the night, receiving green forage if it is yet upon the farm, or else receiving hay. By the 1st of October they should generally be put upon hay and corn.

This, then, forms the circle of feeding of the horses of the farm :—They are put on hard food by the beginning of October, receiving hay and a medium allowance of oats. In the months of November, December, and January, their hay may be withdrawn, and they may be put on straw, receiving a moderate allowance of oats. In February, they are again put on hay with a full allowance of oats, until about the commencement of June, when they are put on green food, with a lessened allowance of oats, and either fed entirely on cut forage, or pastured during the night, receiving cut forage during the intervals of work in the day.

In the practice of feeding farm-horses, the utmost care must be taken that they never be allowed to get out of condition. In this case, not only are they unable to perform their work, but it requires a much greater expense to bring them again into order, than it would have required to keep them so.

In feeding horses, even when upon hard work, a practice has been introduced of keeping them entirely on boiled or steamed food, with chopped hay or straw, The proportions of the different kinds of food employed in this manner are not subject to rule. But about $\frac{1}{4}$ in weight of the whole may consist of the chaff of straw, $\frac{1}{4}$ of the chaff of hay, $\frac{1}{4}$ of bruised or coarsely ground grain, and $\frac{1}{4}$ may consist of boiled potatoes. To this should be added about 2 oz. of common salt. From 30 to 35 lb. of this mixed provender, or on an average $32\frac{1}{2}$ lb. in twenty-four hours, will suffice for a horse.

Two methods may be adopted in the giving of this food. Either the whole substances may be mixed together, and a certain proportion given to the horses three or four times in the day, or the dried food alone may be given during the first part of the day, and the steamed food mixed with a portion of the dried food in a mess at night.

In the first case, that is, when the whole mess is to be mixed together, the potatoes or other steamed food are first to be prepared, then weighed and mixed with the chopped straw or hay, and with the bruised oats. The quantity for twenty-four hours

being mixed and prepared, the proportion for each horse is to be weighed and set apart in its proper pail, and given to each horse at three or more times, as shall best suit with the work with which he is engaged, taking care that considerably the largest quantity shall be given at night.

When this method of feeding is adopted upon a farm, it should be confined entirely to the months of winter, for the horses of a farm will always be best and most economically fed during the months of summer on pasture and green forage.

From the mixed nature of our husbandry, the habits of the people, and the attention paid to the rearing of the horse, a long and general preference has been given to this animal for the labours of the farm. In certain districts of England, the ox is still the more common beast of labour; but in by much the greater number, the ox is either unknown as an animal of draught, or employed only partially as an assistant.

The ox is a less expensive animal to rear to the age of labour than the horse; his subsequent cost of maintenance is smaller; he requires less care and attendance, and he is less subject to accidents and diseases. He has this further advantage over the horse, that, at a certain age, when unfit for labour, he can be fattened, whereas the horse declines after a time, and becomes useless. But the ox, though well suited for a slow and steady draught, such as the plough demands, is not so well adapted for active motion or distant carriages as the horse. Although patient of labour, he sinks under extreme fatigue, and is not capable of those sudden exertions which the diversified operations of our agriculture require. The horse, therefore, which unites force of draught with quick action, facility of travelling, and the power of bearing great fatigue, is in these respects better suited than the ox to the varied labours of an extended farm. As agriculture, accordingly, has improved, the use of oxen has given place to that of horses for the common purposes of the farm.

Being thus employed as the principal or only animal of draught

on the farms of this country, being in universal demand for carriages of every kind, and for the innumerable purposes to which he is adapted, the breeding and rearing of the horse form an important branch in the rural economy of this island.

The demand for horses for the saddle, for the lighter and more rapid carriages, and for the heavier labours of every kind, is exceedingly great. The vast supply required is furnished by the farms of the country. Either the farmer directly rears the animals, or he raises the food by which another class of traders is enabled to rear them. The greater number of horses are produced on the farms, and they consume the produce upon the ground until they are of an age to be used. The exceptions are the cases of those particular kinds of horses, as the race-horse and the finer animals for the saddle, that demand an especial attention.

II. THE OX.

1. Species and Varieties.

Of the Ox kind various species are enumerated by zoologists, of which two only enter into the rural economy of Europe, namely—

1. Bos bubalus—The Common Buffalo.
2. Bos taurus—The Domestic Ox.

The Common Buffalo, a native of the warmer regions, has come to us, beyond a question, from Asia. He seems to have been introduced into Italy about the sixth century, and is now an important animal in the rural economy of that country. He is used by the Italians as food, and as the beast of labour, and may be said to form the riches of the inhabitants in many parts of the country. He is cultivated, too, in Greece and Hungary. He prefers moisture, and the rank herbage of marshes. The milk of the female is good, but the flesh is held in less esteem than that of

the common ox. The pace of the animal is sluggish, but from the low manner in which he carries his head, throwing the weight of his great body forward when pulling, he is well suited for heavy draught. But this is not a property sufficiently important to cause the introduction of the buffalo into the agriculture of Northern Europe, and he is not likely, therefore, to be carried beyond the countries where he is now reared.

Of all the species, the Domestic Ox is the most generally diffused, and the most valuable. He has existed in a domesticated state beyond all the records of history and tradition, and naturalists can but conjecture from what parent stock he has been derived. Like all the animals necessary to the subsistence of man, he suits himself in a wonderful degree to the circumstances in which he is placed. Where food is scanty, he scarcely exceeds the dimensions of the deer; but where it is abundant, he reaches to enormous size. He is found from the equator almost to the limits of vegetable life, and is everywhere subservient to the wants and conveniences of the human race.

The female is in a remarkable degree subordinate to the interests of mankind. She is everywhere docile, patient, and humble. Milk, which forms so nutritive an aliment for the human species, is yielded by her with an abundance and facility unknown in the case of any other animal. She has a more capacious udder, and larger mammæ, than any creature known to us. She has four teats, although she gives birth to but one young. Like the sheep and goat, she yields milk freely to the hand, although more abundantly. She yields it after the period of maternal solicitude, whilst many other animals refuse their milk, unless their own young, or some other animal, be allowed to partake of it by sucking them.

From the earliest times, Great Britain has been remarkable for the excellence and numbers of her sheep and oxen, and owes no little part of her opulence to this cause. The varieties of those animals are greatly diversified, both by the different natural circumstances in which they are placed, and by the effects of art in

changing their properties and form. To these varieties is usually applied the term *breeds*.

The principal breeds of British cattle may be thus classified:—

1. The Wild or White Forest Breed, which formerly inhabited, in a state of liberty, the woods of this and other countries of Europe. Remains of this remarkable race have been preserved for generations in the parks of opulent individuals in England, where the animals, herding and breeding exclusively with one another, retain the habits of their wild condition. In other cases they have been reared in a state of domestication, when they assume the habits and essential characteristics of the common varieties. They were formerly numerous in the county of Pembroke, where remains of them are still found.

2. The Breeds of the Highlands of Scotland, spread over all the primary mountainous tracts of that country. These cattle are of small size, covered thickly with hair, hardy, and suited to a country of heaths and mountains. The finest, usually termed the West Highland Breed, are produced in the counties on the western coasts, and the islands of the Hebrides; the smallest in the central and northern Highlands; and the largest towards the eastern coasts, in the districts bordering on the plains. These hardy cattle are reared in vast numbers on the natural herbage of the mountainous country where they have been indigenous from time immemorial, and whence they are transferred, at the suitable age, to be fattened in the lower country. No race of cattle can be better suited to the physical circumstances of the country in which it is reared; and what is to be desired, with respect to its improvement, is not a change of race, but judgment in rearing from the same race, so that the individuals may be brought to the greatest perfection, in form and disposition to fatten, which the nature of the country allows.

3. The Zetland Breed, inhabiting the remote islands of that name, and spreading over the Orkneys. These cattle are of Scandinavian origin, resembling those of Norway. When pure, they are of good form, but they have been greatly injured by crossing.

They are of small size, the horns are short, and the skins soft, and the flesh is finely marbled. The females are better milchers than any of the cattle of the Highlands, and are remarkable for the early period at which they arrive at maturity, and receive the male.

4. The Polled Angus Breed, allied in its essential characters to the cattle of the mountains, but enlarged in size by being naturalized in a country of richer herbage, where artificial food can be supplied. The individuals have dark skins, and are usually destitute of horns. They resemble the Galloway breed in size and general aspect; but they have thinner skins, and less hair; their bodies are less deep; and they rarely possess the fineness of rib which distinguishes the pure Galloways. But the modern Angus is assuming a new character by the care and skill bestowed on its improvement by eminent breeders.

5. The Galloway breed, proper to the mountainous tract of the southwest of Scotland, forming the high land of the counties of Wigton, Kirkcudbright, and Dumfries. These cattle are greatly valued for their hardiness, their adaptation to the purposes of the grazier, and the goodness of their beef. They have deep bodies, dark skins, and are usually destitute of horns. They are indifferent milchers, although yielding good cream. They are carried in great numbers to the pastures of England, chiefly of Norfolk, whence they are transferred to the London and other markets. They are well known at Smithfield, and are there greatly valued by the butchers. This breed being hardy, and well suited to the pastures and moist climate of the districts in which it is reared, every care should be bestowed in increasing its good properties, by selection of the best individuals of the same race for breeding. The breed at one time suffered greatly from want of attention, and from injudicious crossing; but the attention of the Galloway breeders is now alive to the expediency of preserving and improving this staple production of the district.

6. The Breeds of Wales.—These oxen generally exceed somewhat in size the West Highland breed, and, like the latter, are suited to a country of hills and natural herbage. They have dark

or orange-yellow skins, and are generally of a black colour. The finest are reared in the county of Pembroke, in the district of Castle Martin.

7. The Kerry Breed, naturalized in the mountains of Kerry, but spread over all parts of Ireland. The cattle of this race are of small size, and of various colours, with tapering horns. They subsist on scanty food, and the females yielding milk abundantly, are greatly valued by the poorer inhabitants for the domestic dairy.

8. The North Devon Breed, naturalized in the higher parts of Devonshire on the Bristol Channel, but spreading through the lower country. These cattle have the skin of an orange-yellow colour, and are distinguished by their hair being of a deep red, and by their eyes being surrounded by an orange-yellow ring of the colour of the skin. Their general form is light and graceful. Their skins are soft, and their horns of medium length, very fine, and bending rather upwards. They are gentle, active, and above all our cattle suited to active labour. The females are small and deficient in their power of yielding milk, although the milk which they afford is well-coloured and rich in cream. They fatten with sufficient facility on good pastures, and in a temperate climate; but they are inferior in hardiness and the power of subsisting on scanty herbage, to the mountain cattle of Scotland and Wales. They enlarge in size when naturalized in the lower country, so that the breed of South Devon differs in size and aspect from that of the higher lands.

9. The Sussex Breed, a variety of the Devon, and inheriting its properties, but of larger size and less delicate form. The breed has not been cultivated with the same attention to purity of blood as the North Devons. The individuals are not of such uniform colour as the Devons, being frequently marked with white. They are largely used for draught, and are nearly as active in the plough as the Devons, with a greater weight of body. This breed, although now undergoing great improvement by the care of eminent breeders, is as yet little sought after

for the purposes of grazing, beyond the district in which it is reared.

10. The Glamorgan Breed, proper to the county of that name, and common to the high and the low parts of it, but only brought to perfection in the vale of Glamorgan. This breed possesses valuable qualities, and combines well the properties of milching and fattening ; but the improved variety is limited in numbers, and circumscribed in its diffusion by other breeds more generally cultivated.

11. The Hereford Breed, greatly valued for its fattening properties, and extensively diffused for the purpose of grazing throughout the west of England. This breed is proper to the district of old red sandstone which comprehends the county of Hereford. It has a remote affinity with the Devon breed, though the characters of resemblance are not very striking in the modern Herefords. The breed owes all its celebrity to changes begun about the year 1760. The great improver, or rather it may be said the founder, of the modern breed, was the late Mr Tomkins of Kingspion, near Hereford, who, from a very humble stock of cows, but by means of a long course of skilful selection, communicated to the breed its most valuable distinctive characters.

The Herefords are of the larger class of the native breeds. They are of a red colour, with white faces, and with more or less of white on the other parts ; and the tendency of modern breeders is to cultivate more the white colour of the stock. The cattle are of high estimation amongst the graziers of those parts of England where they prevail. The females are small as compared with the size to which the oxen reach, and they partake, too, of the character of the Devon and other allied breeds, in being bad milchers, on which account the modern Herefords are little valued for the regular dairy. The breed, with all its valuable properties, does not now extend itself, the limits of its range being every where pressed upon by the Teeswater Short-horns.

12. The Alderney Breed, reared in the Norman Islands of the British Channel. Of this race the finest are produced in the

Island of Jersey, where they form the riches of the inhabitants, and are attended to with extreme care. The purity of the breed has been there preserved by jealous laws, prohibiting the introduction of foreign animals. They are of small size and ungainly form, with short crumpled horns. They are of delicate constitution, and require a temperate climate, but the females yield a rich and finely coloured milk. It is this property alone which gives all its value to the Alderney breed. Considerable numbers of the cows are imported into the southern counties of England, where they are kept for the luxury of the opulent, or partially employed in the regular dairies to give richness to the milk.

13. The Ayrshire Breed, derived from the county of Ayr, but widely spread over the dairy districts of Scotland, and extending to Ireland. This is the most numerous breed cultivated exclusively for the dairy, in the British Islands. It resembles in certain characters the Dutch or Holstein breed, but its essential characters connect it with the Alderney. The resemblance is so great, that a Jersey cow might sometimes be mistaken for an Ayrshire one. The cows of the district of Dunlop were the first celebrated for yielding milk, and tradition states, that the cows of that district were early mixed with the Alderney breed. But whatever were the progressive steps by which the present race was formed, the dairy breed of Ayrshire, as now cultivated and improved, is well defined in its characters. The individuals are of medium size, of various colours, and have short horns. Their limbs are delicate, their foreheads narrow, their shoulders thin, and their fore-quarters light. This is a form which is valued in the female as indicating a disposition to secrete milk ; but it does not correspond with the form of an animal which indicates a tendency to grow to great size and fatten readily. It is, however, as a dairy breed that the Ayrshire is to be regarded, and the attention of the breeders having been assiduously directed to the characters required, a breed has been produced, suited in an eminent degree to the ends proposed. The cows are capable of subsisting on ordinary pastures, and yield a large quantity of milk in proportion to their size and the food consumed. They

have not acquired the same estimation in the richer dairy districts of England as in their native country. They have been greatly improved within the period of the present century, and the utmost care ought to be employed by the breeders in preserving the purity of the native stock.

14. The Polled Suffolk, or Suffolk Dun, Breed, cultivated for an unknown period in Suffolk and the adjoining counties. The individuals are of medium size, with defective forms; but the cows are admirable for the quantity of milk which they yield under ordinary treatment. The prevailing colour used to be a mouse-dun, and thence the distinctive name of the breed, but their colour is now various. They are destitute of horns in the male and female. The oxen are usually termed home-breds in the market of Smithfield. The breed is losing ground continually, from the want of care on the part of the breeders, and from the effects of crossing.

15. The Falkland Breed, proper to the county of Fife. It derives its name from the royal palace and domain of Falkland, and is believed to have been the result of importations of cattle made during the residence there of the kings of Scotland. It is of the larger class of breeds, of a black colour, marked often with white, and having the skin of an orange-yellow tinge. It has short and very white horns, turned up in a manner sufficient to distinguish it. Unfortunately, this fine variety has been nearly lost in its state of purity; but the traces of it are everywhere to be found amongst the cattle of the adjoining district. The other cattle of Fifeshire are of mixed origin, and scarcely possess such a community of characters as to constitute a true breed. They are generally of coarse angular forms, but they are hardy, and the females are good milchers.

16. The Polled Irish Breed, found in the valley of the Shannon, and spread over different parts of Ireland. This breed is of large size, and well suited to the dairy; but it is much scattered, and is rapidly merging in the races with which it is crossed.

17. The Sheeted Breed of Somersetshire, a variety rendered singular by the contrast of red and white colours on the body. It

is suited to the dairy, but is now in small numbers, which are continually decreasing.

18. The Long-horned Breed, from time immemorial spread over Ireland and the western counties of England. This breed, once the most widely-diffused of the larger races, still occupies a large tract of country, especially in Ireland, where its size varies with the fertility, natural or acquired, of the districts in which it is naturalized. It is frequently termed the Lancashire Breed, from its having been the prevailing one of that county; but it extended in great numbers northwards through Cumberland and Westmoreland, eastward into Yorkshire, and southward to Leicestershire, Warwickshire, and others of the midland counties. In Yorkshire, the district of Craven, lying on the confines of Lancashire, was long celebrated for its breed of long-horns, and afforded bulls to other parts of the country. In the earlier part of the last century, Mr Webster of Canley, in the county of Warwick, was a distinguished breeder of this variety. His stock obtained the name of the Canley breed, and maintained its reputation for a considerable period. But to the Canley breed, and partly derived from it, succeeded the Dishley breed, so named from Robert Bakewell of Dishley, in the county of Leicester, who, soon after the middle of the last century, began those improvements in live-stock, which exercised so great an influence, not only on the long-horned breed of cattle, but on all the races of the domesticated animals of this country. Mr Bakewell chose, as the basis of his intended improvements, the long-horned breed as it then existed; and, by long perseverance and skilful experiment, communicated to it the properties required of early maturity and disposition to fatten.

The older race of long-horns, and great numbers yet remain with the same characters, were distinguished by the thickness of their skins, by the length of their hair, by the largeness of their hoofs, and by a general heaviness of form. Their horns were very long, frequently bending downward. They were deep in the fore-quarters, and comparatively light in the hind-quarters, and they weighed well in proportion to their size. Their milk,

though not large in quantity, was rich in cream, and hence they were not unsuited to the dairy. They were of all colours, but had usually a streak of white along the back. They were hardy, docile, and by these properties suited to heavy labour. From the thickness of their hides, and the length of their hair, they were well adapted to grazing in a moist climate, and on ordinary pastures.

The labours of Bakewell, and of others who pursued the same course of improvement, removed the main defects of the older breed. But although the improved breed possessed many excellent qualities, it has not maintained its place in public favour. The individuals, indeed, fatten readily, and do not require peculiar nicety of treatment; but the quality of the flesh is inferior, the fat accumulates too much on the posterior parts, and the females are bad milchers. For these reasons, but chiefly from the prevalence of a superior race, the Dishley breed has lost all the favour with which it was once received, even in the districts where it was most cultivated.

19. The Short-horned Breed, so named from the shortness of the horns, although this character alone does not distinguish them from other races. It appears, however, that from time immemorial, cattle possessing this character in a degree sufficient to distinguish them from the older Long-horns, inhabited the districts of the fens and several of the north-eastern counties of England. And further, it appears that various importations took place to these parts of England, from the opposite continent, so that a variety of the breed became in time to be distinguished as the Dutch or Holstein breed. It was in the district of the Tees that the greatest attention was bestowed in cultivating this variety for the purposes of grazing. During the last century various individuals distinguished themselves as breeders and improvers of the Short-horns, and at a period comparatively recent, Messrs Charles and Robert Colling of Darlington, in the county of Durham, proceeded with yet more success to complete the improvement of the breed. By judicious and happy selection, the former of these gentlemen did for the Short-horned breed

what Mr Bakewell had before done for the Long-horned. But the improvements of Colling were made on a better basis, and the result was a superior race of cattle. It was not, however, till about the year 1800 that the reputation of the improved variety was fully established, and that it began to supersede other breeds in every part of the country. It is termed the Teeswater Short-horned breed, often simply the Short-horned, and it is now very generally known to breeders as the Durham breed.

This fine variety, by assiduous culture and attention to the properties of form, has now arrived at high estimation. It has become the most generally diffused of all the larger breeds. Although it may be rivalled by individuals of other races, it possesses a better combination of properties than any of the breeds of larger cattle yet produced in the British islands. It is every where extending its limits, and superseding the pre-existing breeds, or modifying their characters by intermixture.

To these breeds might be added a numerous class of mixed characters and origin, but which rarely exist in such numbers, or exhibit such a uniform class of properties, as to admit of their being regarded as true breeds. The most varied of this class are found in the districts of the dairy, where individuals are selected for their milching properties without reference to their common origin.*

2. Improvement of Breeds.

The breed must be adapted to the means, natural or acquired, possessed of supplying food. Art and an improved system of tillage do much in supplying the food of herbivorous animals. By cultivation we can change the nature, and increase the abundance, of the food supplied. But in many cases, tillage is only practicable or expedient to a limited degree, and then the natu-

* The breeds enumerated are classified and fully described in the Author's Work on the Domesticated Animals of the British Islands.

ral pastures of the country must furnish the main supplies of food. In a mountainous country, where the principal food is natural herbage, and where the means do not exist of obtaining artificial food, it would be vain to attempt the rearing of a large and fine breed of oxen. We must, in such a case, be satisfied to rear a race, of hardy properties, of small size, and capable of subsisting on coarse herbage.

Where, again, art, or the natural fertility of a country, admits of supplying sufficient food, the study of the breeder should be to select a race of animals, the best that circumstances will allow him to rear.

Having fixed on the kind of breed which is the best suited to the circumstances of the district or farm, the practical question to be determined, is the manner in which a proper breed should be obtained, or the old one improved. There are three methods which may be adopted for this purpose:—

1. The entire change of the existing stock, and the substitution of a different breed, females as well as males.

2. The retaining of the old breed, male and female, and improving them by breeding from the best animals of the same breed.

3. The improving of the breed by crossing with males of a different breed.

When the nature of a farm allows, the most speedy and the best method, certainly, of attaining the end is to change the stock, and to substitute females of the improved one from which it is proposed to breed. In this manner the purpose will be effected at once, without the labour or loss of time of improving a defective stock.

The second method is the retaining of the existing stock, and improving it by a selection of the best individuals of the same breed. This is the method which ought to be adopted, if the breed already existing is sufficiently suited to the natural circumstances of the farm, and to the methods of cultivation which can be pursued upon it.

The third method is that of crossing, that is, the retaining of the females, and the employing of males of a different breed.

This method has often led to disappointment, from the nature of the crosses attempted, especially where the crosses have been violent, as between animals of very different characters. The first cross in general will be good, but in breeding from the progeny of this cross, expectation will often be disappointed. Not only do the good qualities of the first cross not always remain in the progeny, but often there are found in it defects which cannot be traced to the parents.

This, however, generally arises from injudicious crossing, and from unacquaintance with the principle on which the crosses of different animals should be conducted. When a cross is made, it should be with a male of a superior breed; and in this case the first cross will be almost always a good animal. To secure the full benefits of the cross, however, we should not too hastily resort to the males of the inferior stock, because it might be found, that, while we had injured the original breed, we had not substituted a better in its stead. The general rule, therefore, should be, to cover again the first cross with a superior male of the same breed, and so on, until the good character of that breed became permanent in the progeny. This is said to be breeding up to the superior stock.

In crossing, the essential characters of form are imprinted on the offspring by the male; and it is surprising in how great a degree this imprinting of better characters takes place, when a male of superior breeding is employed. A first cross between a short-horned bull, for example, fully bred, and a very ordinary cow, produces, not only often, but generally, a fine animal, with an extraordinary aptitude to fatten. Many of the very fat animals that receive premiums at the cattle-shows in this country, are extreme crosses of this kind. But the benefit may end with the progeny, if we do not again cover with a male of the same superior breed, and so on until the good characters become permanent.

When a breeder, then, is to improve his stock by crossing, he ought to select a male of undoubtedly superior blood. And he should not generally, after the first cross, resort to the males of

the inferior breed, but to those of the superior one, until he has formed, as it were, a breed for himself. There are, indeed, numerous cases in which a single mixture of better blood will do good, as with those inferior breeds which have no fixed characters. These will be improved by even the slightest intermixture with the blood of a better race; and a farmer who is in a district where this class of animals prevails, may avail himself of a good male, in the same manner as a breeder of horses would do, although the stallion were of a different character from the native stock. The cases where crossing of any kind is to be attempted with caution, are, when a breed of established good characters, or of characters which fit it for the nature of the country and the state of its agriculture, already exists.

In crossing, then, the rule is, to breed from a male of superior stock; and, fortunately, in this country we have now a breed of such established character, that no mistake can arise in the selection of males. These have been formed to our hand with all the care that art can bestow in improving the form of fattening animals. There is no need, therefore, for those mistaken attempts at crosses which were sometimes made with males of questionable characters, as between an Ayrshire cow and a Galloway bull, and *vice versa*. We can predicate nothing securely of the progeny of such crosses as these, the effect of which will probably be to destroy the good properties of either breed, as the aptitude to yield milk of the Ayrshire, and the hardy and fattening qualities of the Galloway. But in crossing with a breed so highly cultivated as the short-horned, the breeder has the assurance that he will produce animals of large size and good fattening properties. He is to consider, indeed, whether he has the means at his command of rearing the larger animals; and if this be so, it will be better that he at once form his stock upon the best model, than run the hazard of wasting time and capital on questionable crosses.

And it must be regarded as highly important as a mean of improving the live-stock of Great Britain, that a breed has been formed, by long-continued selection and care, which may always be

resorted to, to effect the purposes required, in the same manner as recourse is had to horses of known pedigree, to communicate their characters to their progeny. In this manner the labours of those who have improved the short-horned breed, have extended far beyond what the original breeders contemplated. They have not only improved a peculiar breed, but have furnished the most efficient means that can be used of improving the live-stock of the entire country; and it is to be trusted that the breeders of this class of animals will have encouragement to maintain the characters of the breed with as much care as is used in the case of the race-horse, seeing that it is for a far more important end.

But having selected the breed, or having fixed on the means to be employed for forming it, a point to be determined is the manner of maintaining or improving it, by the selection of good individuals, male and female; for it is to be observed that it is equally determined, in the case of the ox as of the horse, that the properties of the parents are conveyed to the offspring. The male undoubtedly acts the principal part in impressing his characters on the young. But the form of the female is of the utmost importance; and if we hope to arrive at success in breeding, the form and characters of the female must be no more neglected than those of the male.

Now we might breed either from animals nearly allied to one another in blood, as brothers and sisters, parents and their offspring, technically termed breeding in-and-in, or from animals of different families. By the latter method are produced animals more hardy, and less subject to disease; by the former, we are frequently enabled to produce animals of more delicate form, and greater fattening properties, and above all to give a greater permanence to the characters of the parents in the offspring. It is known that Bakewell and other breeders were enabled by this system to give and perpetuate the peculiar characters of their stock. These first improvers, indeed, found the practice to be, to a certain extent, necessary, because they could not resort to

the males of other families, without employing inferior animals, and so impairing the properties of their own breed.

It is to be observed, that the breeding and continuing to breed from animals very near of blood, produces animals which have a greater tendency to arrive at early maturity, and to become fat. This seems to result from a tendency to premature age in the animal, which thus more quickly arrives at its maturity of bone and muscle, and so begins sooner to secrete fat.

The system, however, of breeding from animals near of blood has its limits. Nature will not be forced too far for our purposes. It is known that, although this joining of animals closely allied diminishes the size of the bones, and gives a tendency to fatten to the progeny, it renders them also more delicate and subject to diseases. Although, then, this near breeding may be carried to a limited extent between very fine animals, for the purpose of rendering their qualities permanent in the offspring, we do a violence to nature when we carry it too far. The progeny, along with their early maturity and aptitude to fatten, become feeble; the cows cease to secrete milk in sufficient quantity to nourish their young; and the males lose their masculine characters, and become incapable of propagating their race.

When, therefore, the stock of any farmer has become too nearly allied, he ought not to fail to change his males, and procure the best of the same breed. This is essential to preserve the health of the stock for any time. Great losses have been sustained by breeders who have carried the system of close breeding too far, with the design of pushing the improvement of their breed to its limits.

A character of a breed not to be neglected, is size of the individuals. Although large animals consume more food than small animals of the same species, yet they do not consume food in proportion to their greater size; and hence the benefit of rearing the larger animals, if the natural or acquired productiveness of the farm will allow it. But although size be an important element in the character of a breed, there is another property to which

that of size is subordinate, namely, that of a disposition to quick fattening and early maturity. This property depends not on size, but on a different class of characters.

3. Form.

The principal purpose in rearing oxen in this country, is to produce flesh. The rearing of females for milk is, doubtless, also important; but in the great majority of cases, this purpose is regarded as subsidiary and subordinate to that of fattening.

There are certain external characters which indicate a disposition in the animal to become fat, and certain characters which shew that the animal has less of this property, and does not quickly arrive at maturity. These characters are familiar to breeders, and a knowledge of them is readily acquired by practice and observation. But before attending to these characters, it will be well to consider in what really consists the property of quick and easy fattening.

The flesh of an animal consists of muscles. A muscle is a combination of threads or fibres, bound together by a sort of minute mesh-work, to which the term cellular tissue has been applied. Each thread or fibre is divided, so far as the eye assisted by powerful glasses can discover, into smaller fibres still. A number of these smaller fibres or filaments form a fibre; a number of these fibres form a fasciculus, or bundle of fibres; and a number of these fasciculi form a muscle. Now, surrounding and intermixed with the fibres, the fasciculi, and the muscles, is the unctuous substance, fat. The same matter is formed between the muscular substance and the skin, and surrounds and is intermingled with the various viscera within the body. It surrounds, in large quantity, the heart, the kidneys, and other organs.

The muscular fibre grows with the animal, and is essential to its existence and power of motion. When the animal arrives at its full growth, little further addition can be made to the muscle; but it is otherwise with the growth of fatty matter. When the

food which the animal assimilates by the action of its organs, is no longer needed to be converted into muscle, it is converted into fat, and this being intermingled with and surrounding the fibres, the fasciculi, and the muscles, the muscle becomes enlarged. By feeding an animal, then, we have little power over any increase of the muscular substance, but we have a great one over the fatty substance, which, along with the muscle, forms food.

Now, an animal that arrives soon at maturity with regard to the growth of his fleshy fibre, and tends readily to secrete fat, is the kind of animal best suited to the purposes of the breeder and the grazier. Such an animal is said to be a quick grower, and kindly feeder. And the external characters which indicate these properties are a wide chest, and a round capacious body, the first containing the organs of respiration, the latter the stomach and other viscera employed in the process of digestion. In all cases, it is found that the property of fattening quickly is combined with this form. An animal having a wide chest and round trunk requires a less quantity of food to produce a given increase of weight, than one whose chest is narrow and whose sides are flat. When we look for a fattening animal, therefore, we require that his chest shall be broad, and his ribs well arched; and where this form exists, the back will likewise be wide and flat. We require, too, that the body shall be large in proportion to the limbs, or, in other words, that the limbs shall be short in proportion to the body.

Further, it is seen, that, in animals indicating a disposition to fatten, there is a general rotundity of form,—as where the neck joins the head, where the shoulder joins the neck, and so on,—and that there is a general fineness or smallness of the bones, as of the limbs and head. The limbs being short, the neck is not required to be long, and shortness of the neck, therefore, is a character indirectly connected with a disposition to fatten.

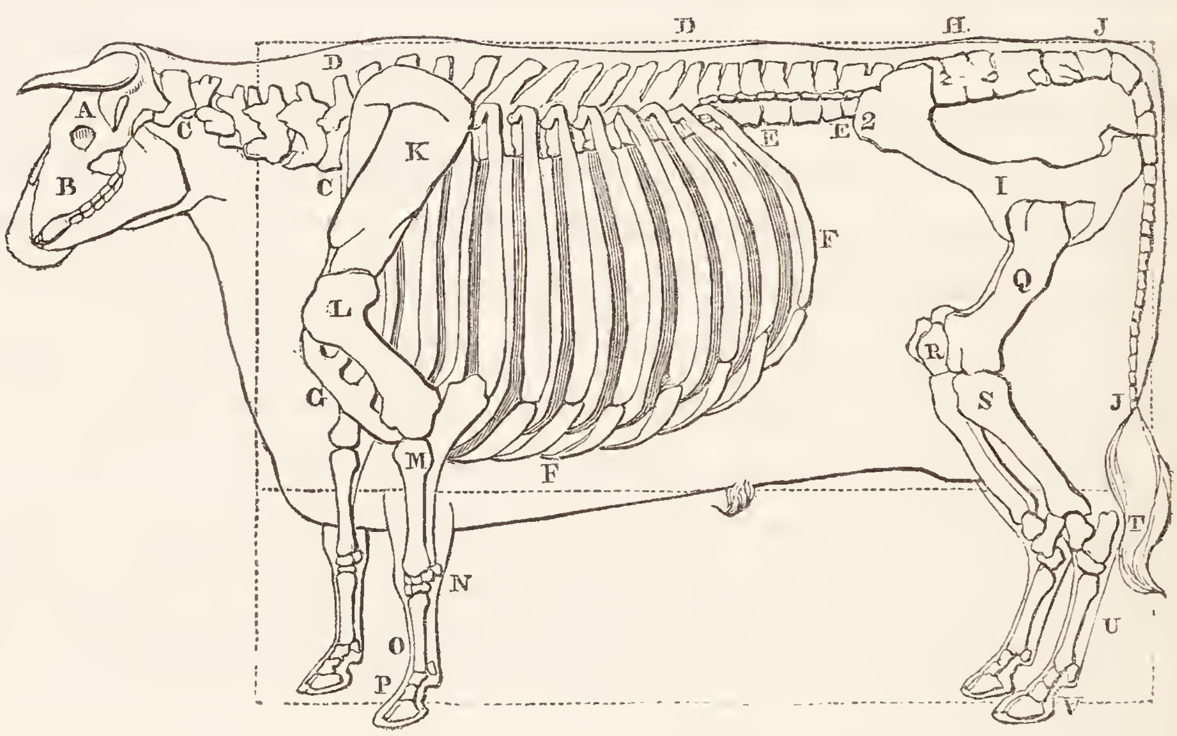
In the case of the horse, it was seen that the body, abstracted from the neck and head, is comprehended within a square, the body occupying about half of the square. But, in the case of the ox, the body is comprehended within a rectangle, as in the

following figure, and the body occupies more than the half of the rectangle.

In the one case, there is the outline of an animal fitted for speed; in the other, of an animal with great bulk of body, and unfitted for active motion. The horse which occupied too much of the square, would be regarded as of bad form, in so far as speed is concerned. In the ox, the more of the rectangle which the body occupies, the more does the form approach to that required by the breeder.

The tendency to early growth and fattening quickly is likewise indicated by the touch. This property is known to graziers and

Fig. 199.



CC Cervical Vertebræ.
DD Dorsal Vertebræ.
EE Lumbar Vertebræ.
A Bones of the Cranium.
B Bones of the Face.
H Sacrum or Rump-Bone.
JJ Bones of the Tail.
FF Ribs.
G Sternum or Breast-bone.
I Bone of the Pelvis.
Q Os Femoris—Thigh-bone.
R Patella—Stifle-bone.
S Bones of the Leg.
T Tarsal Bones, or Bones of the Hock.
U Metatarsal Bones of the Leg.
V Phalangeal Bones, or Bones of the Foot.
K Scapula—Shoulder-blade.
L Humerus.
M Fore-arm.
N Carpal Bones.
O Metacarpal Bones.
P Phalangeal Bones.
2. Hip-bone, Huckle or Hook bone.

breeders, who are all familiar with the soft and delicate feel of a good animal. They call it a mellow feel, the meaning of which it is more easy to conceive than define. It is a certain softness combined with elasticity of the skin. The difference between the skin of a coarse animal, and one possessing the peculiar softness here referred to, can, by a little practice, be easily discriminated.

The same characters which indicate a disposition to fatten in the ox, indicate it in the other domesticated animals. The fineness of the bones,—the largeness of the body as compared with the limbs, neck, and head,—the broadness of the chest,—the roundness of the body,—and the soft and elastic touch,—indicate in all cases this property.*

4. Rearing and Feeding.

The period of gestation of the cow is about forty weeks, varying somewhat according to the constitution of the animal. She is sometimes capable of receiving the male during her first year, but he should not be admitted to her until after she has completed her second year.

Some time after having produced her young, the cow manifests a desire to receive the male. This continues for forty-eight

* The following are several of the popular characters which are generally given as indicating the fattening powers of the ox:—1. The head should be fine and tapering to the muzzle, which should be thin. 2. The neck should be free from coarseness, large where attached to the shoulder, and tapering to where it joins the head. 3. The breast should be wide, and projecting well in front of the fore-limbs. 4. The shoulder should be broad, but joining without abruptness to the neck before, and to the chine behind. 5. The back and loins should be straight, wide, and flat. 6. The girth behind the shoulders should be large; the ribs should be well arched, and the distance between the last rib and the hook-bone small. 7. The hook-bones should be far apart and nearly on a level with the back-bone; from the hook-bone to the rump the quarters should be long and straight. 8. The belly should not hang down; the flanks should be well filled up; the legs should be fleshy to the knee and hock, but below these joints they should be tendinous. The tail should begin on a level with the back, be broad at the top, and tapering to near the extremity. The hoofs should be small, the horns fine and pointed, and slightly attached to the head, the ears thin, the eyes prominent and lively.

hours or more, and returns at intervals of a fortnight or three weeks. When the male is admitted to her, she is generally at once impregnated. Should this not be so, the instinctive desire returns, and she must again be taken to the male until she has been impregnated, which is known by the ceasing of these periodical returns.

It is important to the breeder of cattle that the calves should be born early in the season, so as to afford the means of bringing them well forward upon the summer grass.

The proper season for calving is in the months of January, February, and March. When the period of producing the young has arrived, the cow has to be attended to with care, kept in the house, and the birth of the young waited for and assisted when necessary. The position of the fœtus is with the head couched upon the fore-legs. When it is otherwise, the birth is more difficult, and sometimes the calf must be turned into the proper position. But, in general, the parturition of the cow is easy.

The calf, on being born, is to be carried away and placed loose in a pen or crib with clean dry litter. The cow need not be suffered to touch or recognise her young, as this only tends to render her uneasy and distressed by the separation. The cow should then be milked and fed with some nourishing food. Some nourishing gruel should be given; and an excellent food for some time previous to calving, and for some time afterwards, is linseed boiled, or bruised oil-cake dissolved in warm water.

In mountainous countries the cow may be permitted to suckle her calf during the months of summer; and a practice similar to this is frequently adopted with the breeds of the plains. But where a good breed of cows exists, the young should at once be separated from the dam and fed from the pail. The first milk drawn from the cow is viscid, and is peculiarly fitted for the nourishment of the young; for which reason, each calf should first be fed by the milk of its own dam.

The quantity of milk given to the young animal should be as much as it can consume, which will be found to be somewhat more than a wine gallon in the day. The quantity which it can con-

sume, however, will gradually increase to nearly 2 gallons more, or about 3 gallons in all; and this feeding may be continued for twelve weeks, when the animal is to be put into the course of being weaned, and in one month more completely weaned. The milk given to the calf is new milk, that is, milk directly from the cow. The milk, however, may be economised, by employing substitutes to a limited extent, and, in this manner, the milk of one cow be made to rear more than one calf. The best substitutes are farinaceous food, as meal and porridge. Linseed or oil-cake can be given; by using a little of these dissolved in the milk, its nourishing properties may be increased to any degree required. The calf should be fed three times in the day, regularly at a fixed hour.

After twelve weeks, the use of new milk may be given up, and skimmed milk substituted, making it lukewarm, and gradually lessening the quantity; and in the course of one month more, that is, in four months in all, the animal may be entirely weaned.

This, indeed, is more liberal feeding than is usually deemed necessary; yet it is a great error to stint animals in their food at this age, with the view of economising milk. It is from this cause that many stunted animals are to be seen in the hands of breeders, that never afterwards attain to a good size, nor acquire a disposition to fatten.

During the period of feeding with milk, the animals will be taught by degrees to supply themselves with food. For this purpose, when the season is not sufficiently advanced, a bunch of sweet hay, or any green herbs, should be placed within reach of the animals; and a little salt may be given, which they will soon learn to lick, when placed beside them. If the weather allows, they may be turned into a yard for a few hours in the day, and after a time, when the weather becomes mild, into a little paddock, containing sweet grass, housing them at first at night, until they shall be fully hardened to the air.

The males, when not intended for propagating, may be castrated when thirty days old. The operation is easily performed, by two incisions with a sharp knife. An analogous operation is

sometimes performed upon the female, when she is intended for fattening; but the more approved practice is to preserve her entire.

The weaning of the calf, it has been said, may take place at the end of four months. The calf is then merely turned into good pasture during the remainder of the season, and fed like the other stock, and generally along with the cows or oxen; and, as in the case of all growing animals, it should be allowed ample food.

The subsequent treatment of calves necessarily depends upon the nature of the farm, and the species of food which can be supplied. Where there is nothing but coarse pastures and inferior hay, and when no turnips or cultivated forage can be raised, then the stock of the farm must be suited to these circumstances.

The breeders in such cases are generally merely the rearers of the animals. These, when they have reached a certain age, are disposed of to another class of farmers, who have the means to fatten them. A great proportion of the land of Britain and Ireland is better suited for breeding in this manner than for fattening; and a large exportation of animals takes place from all the breeding farms and districts to be fattened elsewhere. The feeders purchase the cattle at such an age as suits their purposes, and keep them on their farms for such a period as they find expedient. This is a division of labour in the breeding and fattening of live-stock perfectly natural, and in an eminent degree favourable to the interests of individuals and the country. It is in this manner that each district and farm is applied, with reference to the production of live-stock, to the purpose to which it is best adapted.

In cases where no other food can be supplied than the natural produce of the farm, the same care and delicacy in rearing are not necessary or practicable, as under a more artificial system of feeding. The cows, in such cases, are usually permitted to suckle their young. During the first winter, the young animals receive such pasture and natural hay as the farm affords. In

the following summer they are kept on the coarse pastures of the farm; in the following winter they are maintained as in the former one, and so on until disposed of, which may be in the second or third, or even sometimes the fourth year of their age. The sooner cattle, under these circumstances, can be brought to maturity, the better is it for the interests of the breeder.

The system of breeding, however, where the nature of the farm is such as to afford a supply of proper food to the animals, and where the finer class of stock is kept, is altogether different. In this case, the principle of the system followed is to afford a full supply of food to the animal, from the birth to the time that it is transferred to the butcher. This principle applies to all animals intended to be fattened.

The calves, after being weaned, are put, it has been said, on good pasture, and fed for the remainder of the season. When the herbage fails in autumn, which is generally by the end of October or beginning of November, the animals should be put in yards, with sheds, into which they may retire for shelter. The number put into one division or yard should not be too great, though this is less important at this period of their life than afterwards. Calves to the number of 20 may be kept together in one yard, provided they have plenty of room; but when animals are of a large breed, it is better that the number should not exceed 10.

The yards should have pure water in each, conveyed to them by pipes, and retained in troughs, to which the animals can have access at all times. Each yard should have, along one at least of the sides, shallow troughs, formed of wood or stone, for the purpose of holding turnips and similar food. The yards should be so dry, that the animals may not be incommoded. The arrangement of these yards, with their sheds, will be seen in the design of farm-buildings afterwards given. Before bringing the calves home for the winter, the yards should be bedded with a layer of coarse straw, or dried stems of plants of any kind. In the middle of each of these yards should be placed one or more

racks (Fig. 200 or 201), for containing straw, and preventing its being strewed about. The best kind of straw is that of the oat, and the rack should be constantly supplied.

Fig. 200.

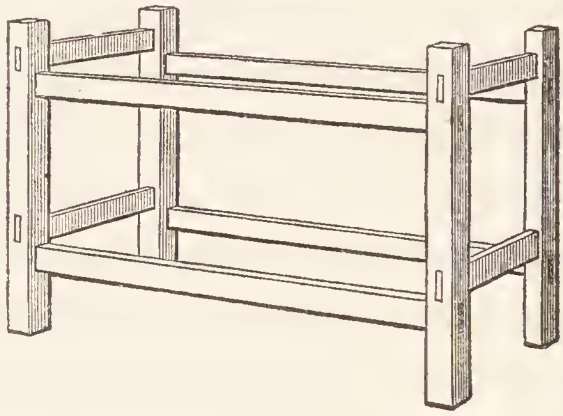
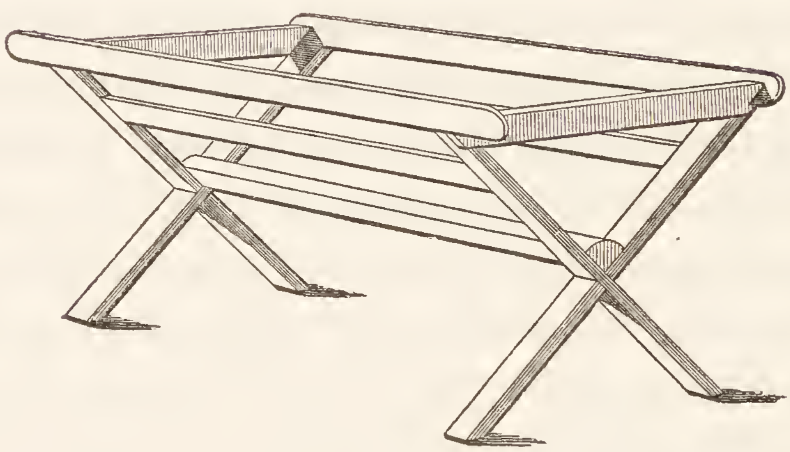


Fig. 201.



A quantity of turnips (for this we may suppose to be the species of green food used) must be put into the troughs in the morning; again a quantity at mid-day; and, lastly, a quantity in the evening before night-fall.

The calves must receive a full allowance of turnips, that is, they must receive as large a quantity as they can consume. At the same time, the racks must be kept always filled with straw, and some litter sprinkled, wherever necessary, over the yards, so as to keep them dry. When straw fails, hay must be supplied, and in place of turnips, should these also fail, potatoes or other succulent food.

In the month of May, generally about the middle of it, in the northern parts of this country, but several weeks earlier in the

more southern parts, the pastures will afford sufficient food for the young stock, which have now completed their first year, and are, in the language of farmers, yearlings, or one-year old. Until the grass is fully ready, the animals should on no account be turned out to the pastures, and care must be taken that the grounds be not overstocked, lest the animals be in any degree stinted in their food. They should at this period be gaining fat as well as growth; and no greater error in the management of cattle can be committed, than to allow their progress to be in any degree checked by the want of sufficient food.

After pasturing for the summer, and at the same period as in the former year, namely, before the end of October, the animals, still yearlings, are taken from grass.

In the case of the finer breeds, the animals may now be prepared for the butcher; for which they will be ready in the following spring, after being fully fed during the winter, or after having received some grass during the following summer. This is the perfection of rearing and feeding oxen, and the practice shews how great must be the superiority of a breed that can be fattened at this early age. It is only, however, the finer classes of animals, and that under a perfect system of feeding, that can be thus early matured. The more common case is, that they require one winter's feeding more before they are ready for the butcher; and it will be better, therefore, to proceed upon this supposition in describing their further management.

The year-olds, then, are to be taken from grass as soon as the pastures begin to fail in October or November. They are put into yards with shelter-sheds as before; but, in place of 20 in a yard, there should not be more than 10, the animals being now of larger size, and more apt to interfere with one another in feeding; and they are to be treated in the same manner as during the first winter. They are to be well littered, to be fed three times in the day with turnips, and to receive their full allowance of straw.

It must be observed, however, that this is the period in the age of the animal at which a slight relaxation may be made in the

system of full feeding,—not that it is well to relax in any degree, but that in practice, with the common supply of food which can be obtained on a farm, it is frequently necessary to do so. But wherever food can be obtained to carry on the system of full feeding during the second winter as during the first, it should be done: for the importance is very great of keeping the animals not only growing, but fattening, from their birth to their full maturity. But if the feeder is unable to carry on the same system of feeding during the second winter as during the first, he may limit the quantity of succulent food, as to the half of the quantity of turnips which the animals, if unrestricted, would consume, giving, however, in all cases, an unlimited quantity of dry provender. In general, however, the necessity for the reduction of the richer food is much less than is supposed, for if substitutes for the turnip cannot be obtained, the quantity of stock may be reduced to the means possessed for carrying it on in a proper manner.

In all cases, then, the study of the feeder must be to carry on the animals with a full allowance of good food from their birth to their maturity. But the period at which he can relax a little in this system of full feeding, and substitute more common provender, is in the second winter. Yet, even while he does relax to the extent of diminishing the more fattening food, he must take especial care that the animals, if they shall not gain fat, shall lose no part of their former condition. It is opposed to all the true principles of breeding to allow animals to fall off from the condition at which they had arrived.

It is not necessary, however, after the first winter, to give the same high feeding to the females intended for breeding, as to the males. The object proposed with the females intended for breeding, is not to render them fat, but to maintain them in a healthy and growing state. This is to be done, not by giving them a full allowance of the richer food, but such a portion of it only as, joined to the more common provender of the farm, will maintain them in a healthy state. When the yearling steers are to be carried on during their second winter, on a modified, and not a full allowance of richer food, then the heifers need not be sepa-

rated from them, because both are to be fed in the same manner; but when the steers are at this time to receive full feeding, then the heifers are to be put into a yard with a shed by themselves. They should not be tied to stakes, according to the common practice, but kept in yards with sheds. In the following summer they are pastured along with the older cows, and receive the male as soon as they are ready to do so, which, in the case of heifers, is later than in that of the older cows. When winter comes, they are to be put into their separate pen again, and fed as in the first winter, and when within a few weeks of the period of calving, they may be tied up gently in their stall, or put into a separate box.

But to return to the fattening stock:—The yearling steers are fed in their yards, either with their full allowance of straw and green food, or else with a full allowance of dried provender, and a modified allowance of green food. By the month of May they have completed their second year, and are now termed two-year-old steers. When the pastures are fully ready for them, they are turned out to feed, and are kept in these pastures until the herbage fails in autumn, when they are to be taken up once more, and fed on green food in the fullest quantity in which they can consume it.

Two methods may be adopted in this final feeding of the animals. They may either be tied in the house, having a trough or manger to feed from, or they may be kept in small yards, with open sheds attached.

Fig. 202.

In the first case, that is, when confined to the house, or fed from a trough or manger, the animals are tied by the neck to upright posts. The best method of attaching them is by a light chain, which encircles the neck, and is fastened to a ring moveable upon the post. In this manner the animal has the power of raising and lowering his head with such freedom as permits him to lie down.

But instead of a series of upright posts, it is better that each animal have his own stall. A partition of wood at the heads of

the oxen, or, a very good substitute, a broad stone, is placed between each animal. A bar of iron is then fastened to the stall, with a ring moveable upon it, to which is fixed the chain which goes round the neck. Two oxen may be put into one stall, in such a manner that each ox shall be prevented from interfering with the provender of his neighbour, in the manner shewn under the head Farm-buildings.

The other system of feeding is in small yards, with sheds. Each shed with its yard should be of a size to contain easily two oxen, or, if it is made of a size to hold four oxen, there should be a division between each pair, so that more than two shall not be together; and in the open yard, and close to the wall, should be fixed troughs for holding the provender.

Under this system of feeding, the animals have more freedom than when fed in close houses; and that moderate exercise, which, without impeding their fattening, tends to keep them in health. They receive the benefit of the sun and air, and have always the shelter-shed to retire to. They have the power of going to their food at all times, even during the night, and this food being in the open air, is kept always fresh. The treatment of the cattle, too, in these sheds and yards is easy, and the injurious effects to the animals obviated of any deficient ventilation, or any want of care in the management. And experience has fully shewn that the finest animals may be fattened in these sheds equally well as in the warmest house when they are tied to the stake.

But the latter practice of feeding is the more common; and it is the most necessary, too, to be described, because it requires greater attention on the part of the keeper.

When the cattle are, for the first time, to be fixed to their posts, some care is needed to induce them to go forward. Gentle means must be employed; they must be somewhat tightly tied at first to prevent their turning round, and watched for a time lest they injure themselves by struggling. They must be well littered, and the turnips placed in the low manger of the stall before them.

Early in the morning the first operation to be performed is, to remove the dung from behind the cattle, and to place the turnips in the stall, the stems and tap-roots having been previously cut off. While the cattle are feeding, the dung is to be wheeled out of the house, and deposited in the yard or dung-pit. When the turnips are eaten up, a little good oat-straw or hay may be placed before the animals; and being now littered, they will soon lie down and chew the cud.

At mid-day they are again to be fed as before, and again before sunset, a little provender of hay and straw being placed before them after each meal; and finally, the keeper, before retiring for the night, is to examine them with a light, see that all is right, stir their litter, and place a little hay or straw before them. Under this system the oxen will be fully fed, and induced during the intervals of feeding to lie down, and left to repose during the night; or they will take a little dry food, should they be inclined to feed. Early in the morning the same process recommences; and the utmost regularity is to be observed in these operations, for the animals know the precise time of feeding, and become restless when it is not observed. They should be regularly rubbed with a wisp of straw. Careful feeders even currycomb their cattle, and in all cases observe that the skin is kept free from vermin, or other impurity.

Frequently the turnips are cut into slices by the turnip-slicer (Fig. 49 or 50). This, though not essential, is very beneficial, by enabling the animals to take the turnips more easily into their mouths, and masticate them. In spring the white turnips decay, and then there should be a succedaneum, first of yellow, and next of Swedish, turnips, which last retain their juices the latest in spring.

If the animals are kept in the yards with shelter-sheds, the principle of feeding is the same as that described; but the dung in this case is not removed from the animals, the litter being spread above it.

An ox of 50 or 60 stones weight will consume about a ton

of turnips in the week, or about an acre in 24 weeks. If he thrive well, he will gain in weight 14 lb. or more in the week.

Sometimes cattle, especially when tied to the post, are apt to be choked by a piece of turnip sticking in the throat. In this case, the common practice is, to endeavour to push the piece of turnip gently, but firmly, down into the stomach by means of a flexible stalk, terminating in a round bulb of wood or bone.

The feeding with turnips is the most simple and economical method practised in this country. Turnips, however, cannot in all cases be raised in sufficient quantity, and in such cases they cannot be produced at all, and then, if a system of feeding is to be carried on, recourse must be had to other substances.

Mangel-wurzel, the carrot, the parsnep, and the cabbage, are all suited to the purpose of feeding; and the manner of consuming them is so similar to that of the turnip, that when the mode of applying the one is known, that of using the others is easy.

Potatoes are also a nourishing food for ruminating animals. When given raw, they are applied in the same manner as the turnip; but care should be taken to begin somewhat gradually, because this food is apt to scour and injure cattle at first. Potatoes and turnips may, with great advantage to cattle, be given at the same time. Different kinds of food have an exceedingly good effect in promoting the tendency to fatten of all cattle; and in the case of feeding with potatoes and turnips, one meal of the former, and two of the latter, in the day, will be found to be a good arrangement. Potatoes boiled or steamed may be given to oxen; but boiled food is never of the same advantage to ruminating animals, as to animals with single stomachs, as the horse and the hog.

Bruised corn and meal are occasionally employed in feeding; but these are expensive, and only subsidiary to more common food.

Another species of food is the refuse of the distillery. This consists of the grains of malt after distillation, and of the wash or liquid refuse, and wherever these can be obtained, they may be applied to the feeding of cattle with success. They form a very

nutritive food, rejected often at first by the animals, but afterwards consumed by them with eagerness. The grains may be given at the rate of from a bushel to a bushel and a half in the day, with a proper supply of dry food: the liquid portion, or wash, is drunk by the animals. The refuse of the brewery is in like manner used for the fattening of oxen.

Oil-cake is one of the substances employed in feeding. It is highly nutritive, is greatly relished by cattle, and it never fails to increase their tendency to fatten when given with their other food. It may be given in quantities of 2 lb. or more in the day, along with any other food. It is frequently given with hay alone, and the quantity that will feed an ox is from 12 to 15 lb., with half a stone of hay in the day; but this is an expensive method of feeding, and the better mode of using oil-cake is to give it in small quantities, with less costly provender. It may be given with great benefit along with turnips. In this manner the turnips upon a farm may be economised, and a much greater number of animals nurtured upon it than would otherwise be practicable.

Salt should be given in limited quantity to fattening animals. The use of this universal condiment in the feeding of oxen, has been known from the earliest times. It does not directly tend to the secretion of fat, but it preserves the animals in health, and thus produces the result indirectly. The quantity given may be from 4 to 5 oz. in the day to old oxen, to yearlings from 2 to 3 oz., and to calves ½ oz. All oxen will soon learn to take it if placed within their reach.

The general method of feeding oxen in this country in summer, is in the fields in the manner described; and this is the more simple and easy method, and that which is the most likely to be generally followed in a country abounding in pastures. The practice of soiling, however, has been often recommended, and partially adopted, in the feeding of oxen. But this has usually been in favourable situations with respect to productiveness of the soil. It is not a practice well suited to very young stock, which require moderate exercise, and do not thrive so well, when

kept and fed in this manner, as when allowed to pasture in the fields. Soiling, therefore, when it is practised in any case, should generally be confined to the older stock, at the period of their final fattening.

The best method of keeping oxen when soiled is in the same small sheds and yards as are employed for feeding on turnips. The food must be carried home, and given to the cattle from racks in moderate portions at a time. They must be fed three times, and may be fed four times, in the day: and they should be kept carefully littered. Between the period of consumption of the first crop of clover or other green forage and the second, there is sometimes an interval. At this time, therefore, there must be a supply of other food, as of tares, which, if sown in the preceding March, will be ready at this time, and will carry on the cattle until the other forage is ready for being cut a second time.

The rearing and feeding of cattle has been described from the birth to the maturity of the animals; but deviations from the modes described necessarily take place:—The breeder in the case of certain farms, is not the feeder: He merely rears the animal to the maturity of age, or degree of fatness, which the nature of his farm allows, while other persons complete the process of fattening, in the manner which their peculiar situations render profitable or expedient.

The hardier breeds of the mountains are in general request for being fattened in this manner. They are generally purchased lean before winter, and taken to all parts of the low country. They are there fed on straw, or coarse natural hay, during the first winter, with merely such an allowance of green food as can be spared; and they are either grazed and fattened in the following summer, or fed for another winter and summer, as suits best with their age and condition.

And not only the mountain breeds, but lean cattle of all kinds, in a more or less advanced state of age and fatness, are in the course of being transferred; and a great part of the profit of farmers depends upon the skill with which, on the one hand,

they make their purchases, and, on the other, effect their sales of stock.

Calves, instead of being reared to maturity in the manner described, are frequently disposed of in a fattened state when young. The calves, under this system, may be transferred soon after their birth to the butcher, or they may be fed for a longer period on milk. In the latter case, they are rarely good veal in less than five or six weeks, and the most approved period for keeping them is ten weeks. They are fed liberally on milk; but linseed cake and other fattening substances may be also employed. The cribs in which they are kept should be perfectly dry, well littered, and ventilated.

5. Weight of Oxen.

The parts of an ox to which the term *offal* is usually applied, are the head and feet, the tallow, the hide and horns, and the entrails.

The fat of an ox, it has been said, is that unctuous substance which is intermingled with, and surrounds, the muscles and other parts. That which grows internally is mostly termed tallow, and is generally considered to be of the same value, weight for weight, as the flesh of the fore-quarters; and so likewise is the hide. These, and the other parts termed offal, are commonly regarded as forming about one-fifth of the value of the animal. When beef is said to be sold at a certain price *sinking the offals*, the meaning merely is, that the whole price of the animal is reckoned upon the carcass alone; hence, when beef is sold at a certain price sinking the offals, that price is more than if it were sold without including in it the price of the offals.

That portion of the ox which is used for food exclusive of the offals, is usually termed the quarters, because the animal, on being cut up, is divided into four parts or quarters. The most esteemed parts for food are the hind-quarters. These weigh somewhat less

than the fore-quarters; though the more perfect the form of the animal is, the more nearly do the fore and hind quarters approach in weight.

Practice enables persons to judge of the weight of animals by the eye alone; but it is convenient to be able to ascertain the weight by measurement. This may be done with considerable correctness in the following manner:—When the animal is standing in a natural position, measure his length in feet from the foremost upper corner of the shoulder-blade in a straight line to the hindmost point of the rump; then measure the girth or circumference immediately behind the fore-legs; multiply the square of the girth by the length, and this product by ·238, which will give the weight of the quarters in stones of 14 lb. each. This rule has been arrived at by regarding the body of the animal as a cylinder, and determining, by experiment, what proportion, on an average, the actual weight of the quarters of animals bears to the cylinder.

Another method of ascertaining the weight of fat cattle, is, by weighing them when alive. One-half of the live-weight may be considered as equal to that of the four quarters; but in the case of fully fattened animals, a more correct result will be arrived at by multiplying the gross weight by six-tenths. This rule has been arrived at, by determining, from an average of cases, what proportion the dead weight of the four quarters is found to bear to the living weight of the animal.

6. Diseases of Oxen.

The diseases of the larger ruminating animals are not of very frequent occurrence, although they are often dangerous and fatal.

A malignant distemper, termed Murrain, has sometimes made dreadful ravages among the cattle of many countries, returning for successive years to the same country, and sweeping entire generations of cattle away. In the early part of the 18th century, it long raged on the continent of Europe, and when it visited this

island, continued its ravages for many years. But happily, since the period of its first introduction, its occurrence has only been partial and local.

Cattle are subject to inflammatory diseases, which receive various names, as quarter-ill, black-quarter, shewing-of-blood, &c. Bleeding at the commencement of these diseases is proper; but the subsequent treatment depends upon the stages of the disease at which the remedies are applied, and other circumstances.

Cattle are subject to colds, which frequently terminate fatally. Colds are brought on, amongst other causes, by sudden changes of temperature, whether of the atmosphere or of the place of feeding of the animal. Bleeding will, in most of these cases, be proper; and, in all cases, shelter should be afforded, and warm food supplied, as mashes, boiled turnips, and the like.

Cattle are subject to different diseases, which receive the general name of cholic or gripes. Diarrhœa and dysentery are also diseases of cattle, and many diseases might be mentioned; but it would be of no avail to enumerate them, without entering into details.

In general, what falls within the province of the farmer may be comprehended under the head of food and general treatment. The medicines which he should venture to administer should be cautiously given. Where violent inflammatory diseases attack the animal, he may always venture to bleed in the first stage; when costiveness occurs, he may administer some laxative medicine; when diarrhœa or looseness occurs, he may give some laudanum, and in all cases mashes of boiled or steamed food. The bleeding of the ox, it is to be observed, should always be large.

One of the diseases of cattle, with regard to which the farmer has to act upon the instant, is hoven, or inflation of the rumen. The paunch, or first stomach, of ruminating animals, is of large size, and as the green food which is taken into it is frequently charged with moisture, the stomach is not only overloaded, and unable to carry on its functions, but the mass fermenting, air is generated, by which the stomach becomes so distended, that either a rupture of it takes place, or the animal dies of suffocation. This

disease most frequently occurs when animals are turned into rich succulent pastures, particularly of clovers, when charged with the morning dews.

Sometimes stimulants are given to assist the action of the stomach, of which the best is linseed oil and oil of turpentine, in the quantity of 1 lb. of the former, and 2 or 3 oz. of the latter. Sometimes a hollow flexible tube is introduced into the stomach through the mouth, that the air may be permitted to escape. Should this operation not succeed, then an opening must be instantly made through the left side into the paunch. This is usually done by a pen-knife, while a quill, or something similar, is introduced, to allow the air to escape. But recently, the stomach-pump has been employed for this and other diseases, and with the best effects. It is fitted to withdraw the contents of the stomach, and also to inject liquids, so that, when the mass of the stomach is too hard, the matter may be first diluted by injected liquids, and then withdrawn. The stomach-pump is also suited to various diseases of the horse, and may be formed of smaller size for the sheep; so that, by means of this instrument, the lives of many valuable animals may be saved upon the farm.

7. The Dairy.

Milk is a secreted liquid intended for the nourishment of the young of mammiferous animals, and to this end it is eminently adapted. By agitating this substance, it separates into two parts, a fluid and a solid. The solid part is butter, having the properties of an expressed oil. The fluid part is merely the milk deprived of its butyraceous part; and when it is obtained by the operation of churning, it receives the name of butter-milk.

But, if milk is left at rest for a time, it becomes acescent, and coagulates. This coagulation takes place of itself; or it may be produced by adding certain substances to the milk, as acids, alcohol, the juices of certain plants, and the gastric juice of animals. The coagulated portion of the milk is curd; which, when

the liquid is expressed from it, forms cheese. The liquid that is thus separated is termed whey. Whey, therefore, is milk deprived of its caseous or cheesy matter.

Again, milk, if left at rest for a time, separates into two parts; a more oily part, which rises to the surface, and is termed cream; and a more serous part, which, when the cream is removed, is termed skimmed milk. A portion of the cream still remains attached to the more serous milk, and the latter is a nutritive substance, employed largely as human food, and for the feeding of calves and other animals.

It is from the oily or creamy part that butter is derived. It may be allowed to rise to the surface, and then being removed from the more serous part, be churned, or the whole, namely, the serous and creamy part, may remain mixed together, and be churned. In either case butter will be obtained. In the first case, the butter will be of better quality; in the second, it will be produced in larger quantity.

The caseous or cheesy matter may be obtained by coagulation from the serous portion of the milk alone. But in this case it is less rich and grateful; for when all the creamy part is left with the milk, a portion of it remains with the cheesy part. Hence, when it is wished to procure good cheese, the creamy part is not removed from the milk before coagulation.

The manner of separating either the butyraceous part of the milk by agitation, or the cheesy matter by coagulation, is so easy, that it is not surprising that the means of doing so should be everywhere known and practised. Butter and cheese form, in all the temperate parts of the world, extensive articles of food; but in warmer countries, the oil of plants is largely used, in place of the oily part of milk.

In the practice of the dairy in this country, milk may be disposed of in three ways.

The first is in the form of milk for food; and this is the most profitable where, from the nearness of the market, and the demand for the produce, it can be adopted. In the vicinity of towns, accordingly, dairies are formed merely for the production

of milk; and these usually form the largest class of dairy establishments. But the sale of milk in its fresh state is necessarily limited to a certain circle around the different markets of consumption.

The next most profitable production of the dairy is butter in a fresh state. This circle is more extended than that of milk alone, because butter can be preserved longer, and conveyed to a greater distance.

At a greater distance still, the produce of the dairy consists chiefly of cheese, or, when butter is produced, it is salted for preservation, and not disposed of in its fresh state. It is for the combined production of cheese and butter that dairies are usually made; and a dairy, that it may fulfil these purposes, should consist of several apartments:—

1. The milk-room.
2. The work-room.
3. The store-room.

The milk-room is intended to contain the milk previous to obtaining from it the cheese or cream. It should have its windows to the north, and be so formed as to preserve a cool and equal temperature. It should be well ventilated, kept dry and clean, and be as much as possible removed from the effluvia of putrid substances. The windows should be formed of gauze-cloth, which may exclude flies but admit the air, and protected from mice and accidents by a grating of wire. This apartment should be kept cool in summer, but in winter heated by a stove or otherwise, so as to maintain a temperature of from 50° to 55°.

The work-room is that in which the different manual operations are performed. It is to be fitted up with a boiler to boil water and heat milk, and it should be of sufficient size to allow of performing the operations of churning, cheese-making, washing the dairy vessels, and the like. But when the dairy is of the larger size, there should be more than one apartment; namely, one for churning, one for making the cheese, and one for cleansing the vessels.

The store-room is intended merely to keep the cheeses when

made. It may be placed wherever convenient, and should have a certain degree of warmth, without being too much heated or lighted.

The Utensils required for a dairy are :—

1. Milking-pails, which may be formed of wood : 2. Sieves of hair or wire-gauze, for the purpose of passing the milk through and retaining the impurities : 3. Vessels for holding the milk until the cream rises upon the surface, and a vessel for containing the cream : 4. Flat dishes of tin, ivory, or horn, for the purpose of skimming the cream from the surface of the milk : 5. A churn : 6. A wooden vat or tub, in which the milk is placed when the curd is coagulated : 7. A cheese-knife, for the purpose of cutting or breaking the coagulated curd, that the whey may be separated : 8. Sieves, or vessels perforated with holes, in which the curd may be placed, that it may be broken, and the serous matter further separated : 9. Wooden vessels, with perforated sides and bottom, in which the curd is placed for being compressed : 10. A cheese-press.

The utensils more especially employed for the making of butter are the dishes for holding the milk until the cream separates, the skimming dishes for removing the cream, a vessel for holding the cream, and the churn.

The dishes for containing the milk are made of various substances, as marble, slate, tinned iron, earthen ware, and wood. Lead is sometimes employed, but improperly, as it may be acted upon by the acid of the milk ; and so likewise may iron, if not defended by a coating of some substance. The milk may either be contained in one large vessel or trough, with a stop-cock at the bottom, so that the milk may be withdrawn, leaving the cream in the trough, or it may be put in separate shallow vessels. These last have been recently made of cast-iron, smoothed within and coated with tin ; and more recently zinc has been employed. Either of the substances is superior to the more common material, wood. They are more easily kept clean, and sooner cooled, which contributes to the more ready separation of the cream.

Churns are of different construction, the most common of which is the plunge-churn, moved by the hand. The form of this domestic instrument is everywhere known. It consists of a cylindrical vessel of wood, placed upright; and the agitation is given to the milk within by a perforated board, which nearly fits the cylinder, and to which is attached a long handle. This being moved up and down, the milk is agitated until the butter separates.

Sometimes, in place of a cylinder standing upright, there is employed a small barrel placed horizontally, and sometimes a square box. Through the box or barrel there passes a wooden axle, to which arms are attached, and motion being given by a handle, the milk is agitated, and the butter separated.

Sometimes in the larger class of dairies, the churn is driven by machinery. The best principle of construction, it is conceived, is that of the plunge-churn, by which a greater agitation is given to the milk, and the operation more effectively performed, than by arms revolving in a uniform direction. The following figures represent a churn of this construction.

Fig. 205.

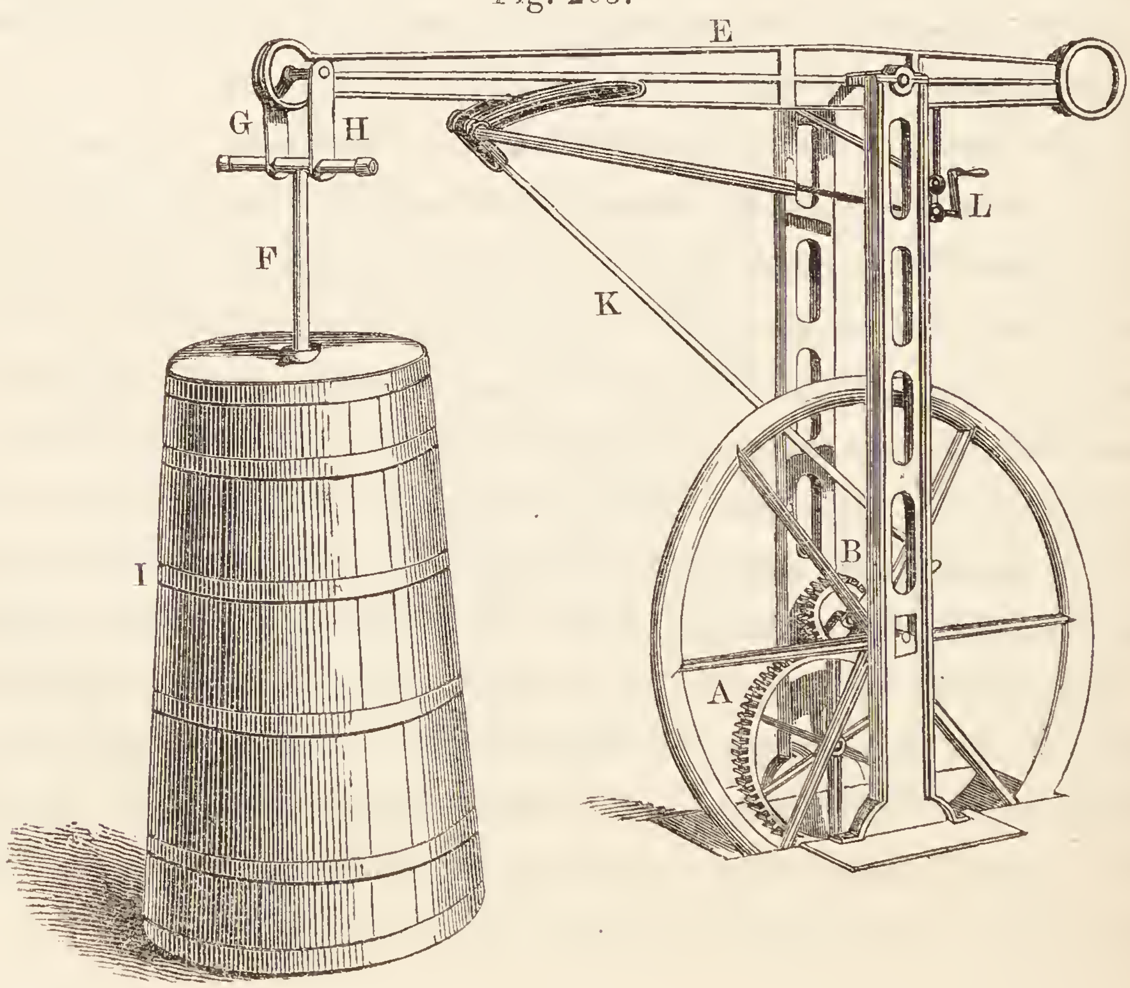
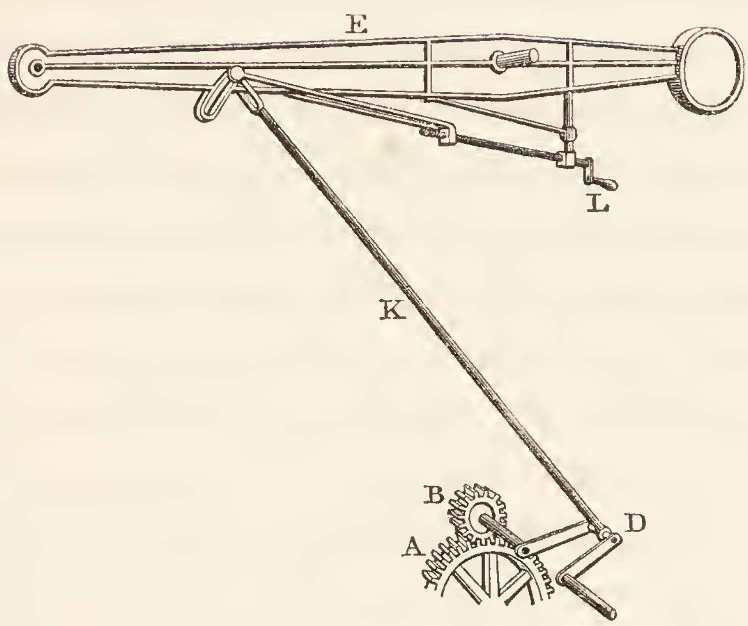


Fig. 206.



If a water-power is not at command, the machinery may be driven by a single horse attached to a shaft at the outside of the building. Motion is conveyed by a lying shaft, to the wheel A, and this, by the pinion B, gives motion to a shaft, on which is a crank D, as seen in Fig. 206. By this crank, and the connecting-rod K, motion is conveyed to the beam E, which is thus alternately raised and depressed. To this beam is attached the handle F connected with the cross-handle GH. This handle passes through a hole in the lid of the churn I, and to the lower part of it is fixed a circular perforated board, fitting the churn. Motion being given to the machine, the handle is raised and depressed, and, by a rapid succession of strokes, the milk is speedily churned. In order to render the strokes longer or shorter, as may be wished, the end of the connecting-rod K can, by means of the screw L, be moved nearer to, or farther from, the centre of motion of the beam. When it is nearer to the centre, the end of the beam makes a larger sweep, and longer strokes are given by the handle. The size of the churn may be sufficient to contain 70 gallons of milk or more; or, there may be two churns, with handles attached to the same beam. This machine has been found to be greatly superior in efficiency and despatch to any that had been before in use.

Butter may be obtained either by separating the cream from

the milk and then churning it, or by churning the milk and cream together. By the first method, the best butter is obtained; by the second, the largest quantity.

When the first method is practised, that is, when the cream is churned by itself, the milk, immediately on being brought from the cow, is put into vessels to cool. These vessels may either be the large trough referred to, or the shallow separate vessels. The milk is put into the trough or vessels from 4 to 5 inches deep; it remains undisturbed for a period of not less than twenty-four, and not more than thirty-six, hours. The cream, which has risen to the surface, is then separated from the milk; in the case of the larger trough, by having the milk withdrawn by a stop-cock; and in the case of the smaller vessels, by the cream itself being skimmed off by a flat dish. The cream is then put into a vessel, until a sufficient quantity of it is collected. Fresh portions of cream are added to this vessel, as they are procured from successive milkings, and the whole soon acidifies.

After a sufficient quantity of cream has been gradually collected, it is put into the churn, and is then churned; and, in the space of an hour or more, the butter will be separated. The best temperature of the cream for the separation of the butter appears to be about 56°, and in cold weather it may be raised to this temperature, or somewhat higher, by the addition of some hot water, or, when the small churn is used, by plunging the end of the churn into hot water.

The butter is now removed, and is washed and carefully kneaded by the hand, but better by a spatula, until all the milk is separated, which will appear by the water coming off pure. After this the butter is fit for present use, or it may be salted for preservation.

This is the method practised when the cream is churned separately; but when the cream and milk are churned together, the practice is somewhat different:—

In this case, all the milk of one milking of the cows is put into the cooling-vessels, so that it may cool down to the temperature of the milk-house. It is then, with the cream, put into a

large barrel, where it becomes acid, and a slight coagulation takes place. It may remain in the barrels from two or three days to a week ; and when a sufficient quantity is collected it is put into the churn, and, after being churned a few seconds, is raised to the temperature of from 70° to 75°, by the addition of hot water. Some do not add hot water ; but the practice is not injurious, and saves labour. In two or three hours, when the hand-churn is used, and in an hour, or an hour and a half, when the larger churn, driven by machinery, is employed, the milk will be sufficiently churned.

By thus churning the whole milk and cream together, a larger quantity of butter-milk will be procured, and of better quality, than when the cream is churned separately. The butter-milk procured in this manner is but slightly acid, and is a wholesome food, agreeable to those who are used to it ; and it is perfectly nutritious, all the caseous matter of the milk still remaining.

When the churning process is completed, the butter is, as in the former case, removed and washed in cold water, until all the milk is separated, and the water comes off pure. In this state it may be formed into rolls for present use, or salted for preservation.

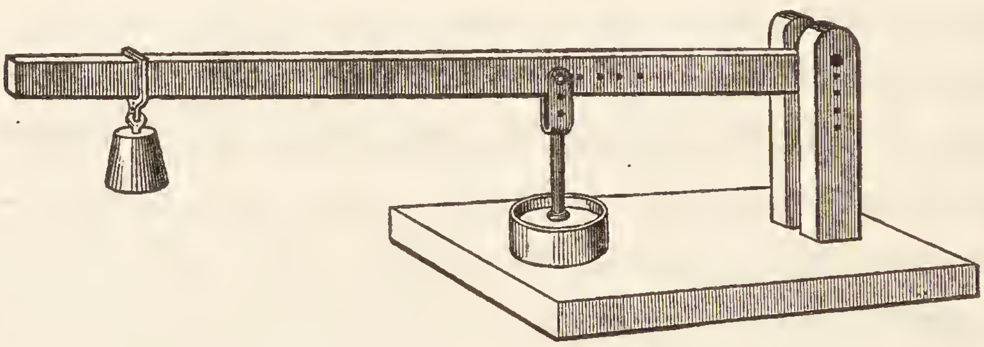
The other preparation of milk is cheese.—Cheese consists of the caseous matter of milk united to a certain portion of the oily or creamy part. This oily portion adds to the flavour and richness of the cheese, and hence, when good cheese is wanted, the cream should not be separated. Cheese, however, can be made from milk from which the cream has been removed ; and it is then termed skimmilk cheese. It may even be made from butter-milk, in which the cheesy part entirely remains. But then the creamy part being more withdrawn than in the case of skim-milk, the cheese wants still more the properties and flavour which are valued in this species of food.

For the making of cheese, the utensils usually required are ;—a large tub, in which the milk is coagulated, and the curd broken ; the cheese-knife, sometimes of wood and sometimes of ivory, with one or more blades for cutting the curd and allowing the whey to separate ; wooden dishes for removing the whey ; sieves, or ge-

nerally another wooden vessel perforated with holes, for further expressing the whey; small circular vats, in which the cheese is placed that it may be compressed; and, finally, the cheese-press.

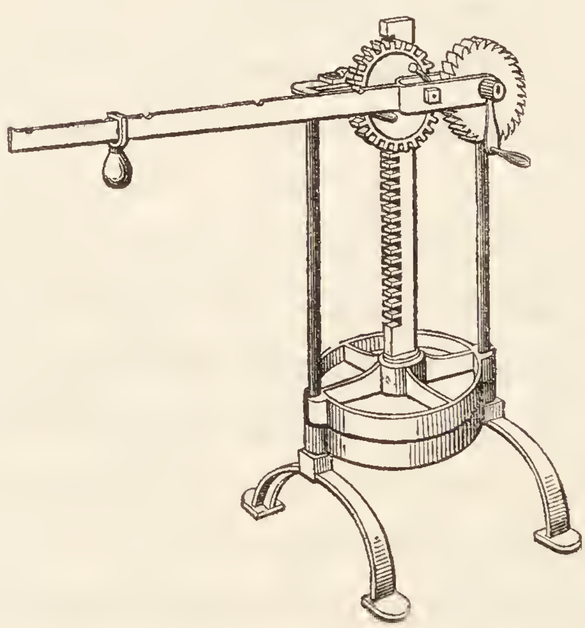
Cheese-presses are of different forms. They are generally made to act upon the curd by the continued pressure of a weight. The most simple is a long beam, made to act as a lever, the cheese to be compressed being placed in its vat between the weight and the fulcrum, thus—

Fig. 207.



But more complex forms of the cheese-press, and, in some cases, more convenient, may be adopted. The following figure represents a press, in which the weight is attached to a lever, and acts on a board which is placed above the curd, by a series of intermediate wheels and teeth.

Fig. 208.



The coagulation of the milk is produced by various substances, but the most approved is runnet, which is prepared from the fourth stomach of a young calf. This substance may be obtained as follows:—

The stomach of a newly killed calf, with its contents, consisting chiefly of chyme and coagulated milk, is to be taken. The matter of the stomach is to be preserved, separating merely any foreign substances that may be mixed with it. It will add to the quantity of runnet obtained to feed the animal largely with milk, some hours before it is killed. A few handfuls of salt are to be put into the stomach and around it. It is then to be rolled up, and hung near a fire to dry; and its quality will improve by hanging it up a year or more before it is used. It is the gastric juice in this runnet which produces the coagulation of the milk.

When the runnet is prepared for use, it is cut into small pieces, and put into a jar, with a handful or two of salt. Water, which had been previously boiled and cooled again, is then poured upon it, and allowed to remain for two or three days. It is then drawn off, and sometimes a second infusion is made, but with a smaller quantity of water. This also remains a few days, and being withdrawn, the two liquors are mixed together, strained through a cloth, and put into bottles, to be used when required.

The usual manner of making cheese is the following:—The milk is put into a large tub, and this as soon after being obtained from the cows as possible. If there be a sufficient number of cows upon the farm to produce one cheese at a milking, the process is performed immediately on the milk being brought from the cows. The milk, after being strained through a sieve, is put into a vat; and, while yet warm, a quantity of runnet is mixed with it, after which the coagulation soon takes place. The quantity of runnet employed depends upon the strength of the infusion. It should be just sufficient to cause the coagulation to be completed in an hour.

If there be not a sufficient number of cows to make a cheese each time they are milked, then the milk, as it is brought from the cows, is put into the milk-vessels, until as much is collected as will form a cheese. When the cheese is ready to be made, the cream is skimmed off, and as much of the milk is heated separately as, when added to the mass again, will raise it to about 90°. The cream which has been separated, is then either mixed

with this heated milk, and so liquified and dissolved in it; or it is not added to the general mass, until the heated milk has been added.

The curd being fully formed, it is cut in various directions with the cheese-knife, so as to allow the whey to exude; and the whey is then lifted out in flat dishes, the curd at the same time undergoing a gentle pressure. The curd is then cut into small pieces by the cheese-knife, and put into a sieve or vat with holes, and then repeatedly cut, pressed by the hand, and broken, until it ceases to give off any serous matter. It is last of all cut very small by the cheese-knife, and a quantity of salt, in the proportion of about half an ounce to a pound of cheese, being mixed with it, it is wrapped in a piece of cloth, and then put into a small wooden vessel with circular holes at the sides and bottom, and placed in the cheese-press; sometimes the salt is not applied until the cheese has been compressed.

The time during which the cheese remains in the press is dependent upon the nature of the cheese and the degree of previous manipulation which it had undergone. In some of the finer and richer cheeses, the pressure is comparatively slight, and in some cases the cheese-press is altogether dispensed with, the curd being compressed by fillets of cloth bound round it.

But in ordinary cases, the cheese, being wrapped in a cloth and put into its vat, with a board above it to fit the vat, remains in the press from one to two hours. It is then taken out, wrapped in fresh cloth, and replaced in the cheese-vat; and then the salt, if it has not been previously applied, is rubbed over the surface. It may then be taken out every five or six hours, the cloth being changed, and the salting repeated. After being pressed in this manner for two or three days, the operation will be complete. The cheese may then be put in a warm place for some time to dry, and ultimately placed in the store-room for preservation.

But great variations take place in the manner of performing the operation of the cheese manufacture; and certain districts are distinguished by their peculiarities of practice. In England, more care is generally employed than is thought necessary under

the system of management adopted in the dairy districts of Scotland.

The richness and flavour of cheese very much depend upon the quantity of cream which the milk contains. In some of the districts of England most celebrated for rich cheese, the cream of one milking is skimmed off and mixed with the entire milk of the subsequent milking. In this way the milk which produces cheese has its own cream, and that also of a previous milking.

It is a frequent practice to colour the milk, so as to give a red tinge to the cheese. This is now generally done by a preparation of the red pulp surrounding the seeds of the arnotta tree. This adds nothing to the goodness of the cheese, but the mixture is harmless.

The residuum after the separation of the curd, it has been said, is whey. This substance is chiefly employed for the feeding of pigs, and is exceedingly well suited to that purpose.

These are the principal details which it is thought necessary to give regarding the preparation of these salutary and nutritive substances. By means of the dairy, a larger quantity of animal food can be obtained from the consumption of an equal quantity of herbage than by any other means. The dairy forms an important branch of public industry, and contributes in a material degree to the support of the inhabitants of this and other countries of Europe.

In the practice of the farm, where the main end is rearing animals for fattening, the kinds of animals will be selected for breeding which are the best suited to the purpose; and the production of milk will be regarded as secondary and subordinate. But when the principal end is the production of milk, then animals will be selected which are the best adapted for yielding rich and plentiful milk.

The form of animals that are best fitted to arrive at early maturity and secrete fat, differs in some respects from that which indicates a disposition to secrete and yield milk. A dairy-cow, like a fattening animal, should have a skin soft and mellow to the touch,—should have the back straight, the loins broad, the extre-

mities small and delicate; but she need not, as in the case of the fattening animal, have the chest broad and prominent before. She may have the fore-quarters light, but the hind-quarters should be relatively broad, capacious, and deep; and she should have a large and well-formed udder. There should be no breeding *in-and-in*, as in the case of a fattening stock. The purpose in rearing cows for the dairy is not to produce animals that will arrive at premature age, but such as are hardy and of good constitution. By long attention to the characters that indicate a disposition to yield milk, the breed of Ayrshire has become greatly more esteemed for the dairy than other animals superior to them in size and fattening qualities.

With respect to the manner of feeding the cows of the dairy, the most economical, perhaps, is feeding them entirely on green forage during the summer, and in winter on carrots, potatoes, parsneps, and cabbages; on chaff and similar substances boiled; on coarse meal, bruised beans, and other farinaceous food; on distillers' wash, and other nutritive substances. This is the manner of feeding adopted in the large dairy establishments of towns; and it is the practice pursued in various parts of Europe.

But in a country of abundant pastures and enclosures, the cows may be allowed to pasture in summer, and be only stall-fed in winter. This is the practice adopted in most of the dairy districts of this country. During the heat of summer, however, the cows should be housed during the heat of the day, and fed at that time on green forage, and turned out to pasture in the cool of the evening.

In winter, the cows of a common dairy may be fed on cabbages, potatoes, and other succulent food: and it is a good practice in many cases to boil or steam a portion of their food, and to mix salt with it, which may be done at the rate of 2 oz. or more in the day for each cow.

In summer, the cows are either milked in the field, or they are driven gently home to the dairy, and milked close to it. Many skilful dairy-farmers prefer the latter practice, in order that the time of the milkers may be saved, and the milk transferred speedily

to the vessels of the dairy. The cows, when in full milk, may be milked three times in the day; at other times twice in the day will suffice.

The quantity of milk yielded by cows varies greatly with the health, constitution, and treatment of the animals. After calving the cow yields her milk in the largest quantity. She, after a time, yields less and less until she approaches the period of bringing forth her young, for about six weeks previous to which she tends to become dry: and this natural provision should be favoured, and not prevented, as is sometimes attempted. If a cow is not in calf, she continues to yield milk for a long period, sometimes for several years.

On a well managed dairy-farm, where a proper breed of dairy-cows exists, and where the cows are fed on herbage and green forage in summer, and stall-fed in winter, the average yearly produce may be reckoned at from 600 to 800 gallons for each cow. Between 2 and 3 gallons of milk will yield 1 lb. of butter; and about 1 gallon of milk will yield 1 lb. of cheese.

III. THE SHEEP.

1. Species and Varieties.

The origin of the Domestic Sheep has been sought for by naturalists in various wild races; but which of these has given rise to the common races has been matter of dispute.

The domestic sheep, whether derived from one or more species, is usually termed *Ovis aries*. The female goes with young twenty-one weeks, and generally brings forth in spring. She produces one, and often two, but rarely more than two at a birth. She yields milk in quantity sufficient to nourish her young, which, in the domestic state, are frequently two at a birth. Her milk produces little cream; but the quantity of caseous matter is comparatively large. This, when made into cheese, is wholesome, but strong-tasted.

The sheep appears to attain its most perfect state as to size and form in the temperate zone. It is there covered with wool, whereas in warmer countries it is more covered with hair, as it also partially is in the colder countries, where its size is likewise diminutive. The wool of the sheep for the most part falls off and is renewed every year; and the period of its falling off is early in summer.

In its ruder state the sheep has horns; but in the domesticated races the horns frequently disappear, and the most valued breeds are entirely destitute of them. The sheep is a very hardy creature with regard to the effects of temperature, its thick coat of wool defending it well from cold and moisture. It has been known to live for a long time under snow. It is a harmless and timid creature, and, in its domesticated state, is dependent upon man for protection and food. In mountainous countries, however, where it is less domesticated, and must trust greatly to its own resources, it manifests its instinctive powers of self-protection. It scratches up the snow with its feet in search of food: it is conscious of an impending storm, and takes the means to secure itself from its violence: it is wary and vigilant, and numbers have been known to combine for defence against beasts of prey. But though, under these circumstances vigilant, and in cases of necessity bold, all the habits of this creature lead it to submit to the dominion of man, and from the earliest times, accordingly, it has been the subservient instrument of our race.

The principal breeds or varieties of British sheep may be thus classed,—

1. The Zetland and Orkney Breed. These sheep exist in the islands from which they take their name. They are essentially the same in the various islands, though, in most cases, they have been more or less crossed with stranger blood. The pure breed is of the variety of short-tailed sheep, which exist in Norway and other parts of the north of Europe. They are amongst the least of our races of sheep. Their fur consists of a fine soft wool, mixed more or less with hair. It is of various colours, white, black, or yellowish-brown; and often it is of a mixed colour of white and

black. It is the Zetland variety which is the most noted for the fineness of its wool. All these sheep are hardy, and suited to the exposed country and barren pastures where they are reared. They would doubtless enlarge in size, were they naturalized in a lower country; but no purpose of useful economy would be served by extending them to other parts of the country. It is rather to be desired that the native stock shall be improved, or a superior one substituted.

2. The Polycerate Breed of the Hebrides. This breed resembles that of Iceland, and was doubtless brought to the islands of Scotland by the Scandinavian rovers. It is nearly extinct, and is of no economical value.

3. The Soft-woolled Breed of Scotland. This breed is the remnant of the ancient sheep of the country. They are of small weight, have horns in both sexes, and bear a soft wool. They are exceedingly wild. They have been suffered to become nearly extinct, although they merited attention on account of their hardiness, their admirable adaptation to a country of heaths and steril pastures, and their remarkable exemption from ordinary diseases.

4. The Breeds of Wales, of the same race as the Soft-woolled Sheep of Scotland. These varieties may be divided into two groups; the first comprehending a race of wild little sheep, inhabiting the highest mountains; the second inhabiting a somewhat lower range, and spread throughout the entire country. It is this latter variety which forms the most important of the breeds of Wales. The breeds are of small size and peculiar form, the hinder extremities being long, as if to fit them for vaulting as well as running. The ram has generally thin white horns; the females are destitute of horns. The wool is soft, and much mixed with hair, and underneath the chin the hair prevails so greatly as to form a kind of beard. The colour of the fleece is frequently dun, brown, or black, and, like the other sheep of Wales, the animal tends to throw off the wool of the neck and shoulders early in spring; for which reason these parts are clipped before winter, and hence it is, too, that the practice of "wool-

gathering" still exists in Wales. These little sheep are exceedingly wild and shy. They rise on their hind legs to browse like goats, and crop the tops of shrubs and grasses. Their mutton is excellent, and numbers of them are fed in all the adjacent plains for the consumption of the capital and other opulent towns. Of the same origin are the Old Radnor, the Anglesea, and other varieties, which, however, are often mixed in blood with the races of the lower country.

5. The Breed of the Wicklow Mountains, similar in its essential characters to the sheep of Wales. The wool of these sheep is fine, with a mixture of hair and coarser wool. They supply the market of Dublin with the smaller mutton, which is held in esteem. They are rapidly disappearing in the pure state from the effects of crossing.

6. The Breeds of Kerry, and the high lands of the west of Ireland, slow in arriving at maturity, and producing a fleece of medium fineness, but irregular and mixed with hair.

7. The Black-faced Heath Breed, inhabiting the central chain of heathy mountains and moors which extend from Derbyshire northwards. These sheep have been long since carried to the mountains of Scotland, and now extend all northward through the northern Highlands to the Pentland Firth. The best examples of the breed are found in Tweeddale and the adjacent districts.

They are of the smaller class of sheep, but hardy, bold, and active: they have horns, and the legs and faces are black; they fatten readily when brought to good pastures, and their mutton is in great esteem.

For an elevated and rugged country, where the chief pasture is heath, this breed is exceedingly well suited. The objection to it is the little value of the fleece, which is the coarsest of the wools produced in this country. This circumstance has in many districts caused a substitution of the Cheviot for the black-faced breed. But although the Cheviot breed is superior to the black-faced in weight and value of the wool, it is not possessed of the same hardy qualities, and the black-faced may therefore be cul-

tivated with advantage in situations to which the Cheviot is unsuited.

The black-faced breed, though well defined, loses many of its characters when naturalized in a low, marshy, or less heathy district. Its wool becomes less coarse; the darkness of its colour diminishes, its legs and face become spotted and grey; and its horns sometimes disappear. Hence this breed is in some places so changed in its external characters, as to have lost much of its resemblance to the parent stock.

8. The Penistone Breed. The black-faced heath breed passes by insensible degrees into those of the ancient commons, lower heaths, and forests; and approximates to the larger sheep of the plains, through the coarse and unthrifty breed of Penistone. This variety occupies an elevated district of the coal-formation on the confines of Yorkshire, Lancashire, and Derbyshire. It is termed Penistone, from the market-town of that name, lying to the south of Huddersfield in Yorkshire. The animals are distinguished by their coarseness of form, especially of the extremities, and in a remarkable manner by their thick muscular tails. The rams are very large in proportion to the ewes.

9. The Cheviot breed, derived from a limited tract of hills in the north of England, and thence widely spread over the mountainous districts of Scotland, and of some parts of England and Ireland. These sheep are heavier than the black-faced. They are without horns, and the wool is fine. They are hardy, active, and well suited to an elevated country.

The mountains where this race of sheep is indigenous, though high, are mostly covered with green sward, and thus differ from the heathy mountains of other parts. The nature of this range of pasturage may have contributed to give its peculiar characters to the breed, and considerable care has for many years been bestowed by breeders on its improvement. In these improvements, attention having been more directed to the form and size of the animals than to the quality of the wool, the latter has increased in quantity, though it has diminished in fineness. The Cheviot

breed presents somewhat different characters, according to the nature of the country where it is reared, and the views of breeders. In those cases where artificial food can be supplied in considerable quantity, breeders prefer a larger form of the animal, with shorter legs. On more elevated pastures, and under less favourable circumstances, they are chosen of a lighter form, and with longer limbs.

The properties to be desired in a mountain breed are, that it shall be hardy, of good form, of sufficient size, and with good wool; and for a combination of these qualities, the mountain breed of the Cheviots has certainly not been surpassed in these islands.

10. The Old Norfolk Breed, reared in the heathy parts of Norfolk, Suffolk, and Cambridge. These sheep are strong and agile, armed with horns in both sexes, which in the male are very long and twisted. Their legs and faces are entirely black. Their wool is short, and fitted for the making of secondary cloths. They are of wild and restless habits. They afford admirable first crosses for the markets of consumption with the Leicester and Southdown sheep, and in an especial manner with the Southdown. But from the effect of this system long continued, the pure old Norfolk is in danger of being lost as a separate variety.

11. The Breeds of the older Forests, Commons, and Chases. These vary in their aspect, size, and properties with the localities in which they have been naturalized. They have often dark or gray faces and limbs, have sometimes horns, and are sometimes destitute of horns, and bear for the most part a short felting wool. They have been continually diminishing in numbers, with the appropriation of commons, and the improvement of the country, so that few now remain without admixture with the more cultivated breeds.

Of these forest breeds two may be mentioned, the Dartmoor and the Exmoor, so named from the districts which they respectively inhabit. The one is found on the high granitic range of the forest of Dartmoor, and the other on a no less steril tract at the source of the river Exe, on the confines of Somersetshire.

The Dartmoor sheep have white faces and legs, and the males have horns. They produce excellent mutton, which has been long known in London under the name of Oakhampton mutton, the animals being killed there, and their carcasses carried thence to London. But the term Oakhampton mutton is applied also to the Exmoor sheep, killed at the same place, as well as to the crosses between these two breeds respectively, and the larger sheep of the lower country. The wild little sheep of Dartmoor are reared in their native pasture of heath, and fattened in the lower country. They are gradually disappearing in consequence of the effects of crossing. They are chiefly crossed by the Southdown or Leicester breeds, and the crosses with the Leicester are preferred. The Exmoor sheep are yet smaller, more wild, and more intractable than the Dartmoor. Both males and females have horns, with white faces and legs. Their wool is long and soft. The males are distinguished by a beard beneath the chin. These sheep are, like the Dartmoor, rapidly disappearing by the effects of crossing: they are giving place to other breeds, and especially to the Cheviots, which have been introduced into this district with great advantage.

12. The Ryeland Breed is one of the remains of the fine-woolled varieties of the western counties, naturalized in Herefordshire. This pretty breed has nearly merged in the crosses that have been formed with it, and remnants only of the pure Ryelands remain. They are of small size and destitute of horns. Their wool is exceedingly fine, weighing about 2 lb. the fleece. They fatten readily, and their mutton is excellent. The Ryelands were extensively crossed with the Spanish Merinos soon after the introduction of the latter into England, and the produce was brought into notice under the name of Merino-Ryeland or Anglo-Merino. Great exertions were made to extend this new cross; but though good wool was produced, the breed itself quickly declined in favour. The effects of these and other crosses are still to be traced in a mixed race of descendants. The defect of the pure Ryeland breed was the smallness of its size; but by judicious crossing, this defect might have been corrected in the pro-

geny, and the Ryeland made the basis of a useful breed of fine-woolled sheep.

13. The Southdown Breed is a race of short-woolled sheep, extensively spread over the south-eastern counties of England. It may be said to be proper to the chalky districts, although now carried to other parts. The individuals are without horns, their legs and faces are gray, and, until improved by breeding, they have the light fore-quarters of mountain sheep. Their wool is short and of good quality, and their flesh is of excellent flavour. They fatten readily, and are well suited to an extensive range of the lighter soils.

These sheep have been reared from time immemorial on the chalky soils of Sussex, whence they have spread into other districts; and their general diffusion has effected a great change on the short-woolled breeds of this country. A considerable proportion of the breed has been little improved; but the greater part has been brought, by the care and skill of breeders, to the highest perfection of form and fattening properties. But in these improvements attention having been mainly directed to the properties of form, the fineness of the wool has been somewhat diminished, though its quantity has increased.

14. The Old Wiltshire is one of the varieties of the large fine-woolled sheep of the central counties of chalk. The Wiltshire sheep at no distant time occupied nearly the whole of the county of that name. They are now almost extinct as a separate variety, having merged in the crosses that have been made with them, or given entire place to the Southdowns. They were the largest of the fine-woolled sheep of England. They were of an exceedingly coarse form. Their heads were large, their limbs thick, and the rams had strong horns. Their fleeces weighed about 2½ lb.; but their bellies were almost destitute of wool. They were very slow in fattening, but their mutton was good, and the wethers arrived at considerable weight.

15. The Dorset and Pink-nosed Somerset Breeds. The Dorset variety, so named from the county of Dorset, has been carried to other parts chiefly within a circuit round London. The male

and female have short horns; and their legs and faces are white. Their wool is good, weighing from 3 to 4 lb. the fleece and upwards. They have a resemblance in form to the Spanish Merinos. The females are prolific and abound in milk, and are remarkable for their tendency to receive the male at almost any season. On this account they are employed to yield lambs for winter consumption; but the rams employed for this purpose are not usually the Dorset, but the Leicester or the Southdown. Allied to the Dorsets, and employed for the same purposes, are the pink-nosed Somersets. These are believed to yield a larger lamb, but not to be such good nurses, or to fatten so quickly, as the true Dorsets.

16. The Isle of Portland Breed, inhabiting the islet of that name, is a variety of the Dorset, though of much smaller size. These sheep have been kept unmixed for an unknown period. They are gentle, and of good form.

17. The Spanish Merino Breed, now partially naturalized, was introduced into this country in the year 1788. Soon afterwards the rams were made to cross the Ryeland, the Southdown, and other fine-woolled breeds of England. George III. had introduced rams of the Merino breed from Spain, and cultivated it with care. In the year 1804, the sale which began of his Majesty's stock attracted great attention to the breed; and, in the year 1811, a society was formed for the purpose of encouraging and extending it.

The result of the crosses with the native sheep did not fulfil the expectations formed. The wool of the native sheep was indeed improved in quality; but this was accompanied by defects in the characters of the animals themselves, not to be compensated by the increased value of the fleece. The sheep of the mixed breed nearly all proved defective in their forms, were slow in fattening, and less hardy than the parent stock.

Flocks, however, of the pure Merinos have been preserved, and the progeny of these has remained superior to the new or cross breeds. The naturalized Merinos retain their natural characters, though the wool becomes longer and heavier than in

Spain, and the body more large. But the entire form of the Merino as a fattening animal is bad, and the return in mutton deficient both in quantity and value. It is in vain that some breeders still contend for the superiority of the pure Merinos: the general judgment of farmers is against them, and with perfect reason.

Could the breeders of this country look more to the fleece than to the weight and value of the animal, as in Spain and the parts of Germany where the Merinos have been naturalized, the culture of the breed might become profitable. But the breeder in England finds it his interest to direct attention mainly to the weight and value of the flesh; and while this is so, it will be more advantageous that this country import the wool of other countries, than that the feeders either adopt an inferior animal, like the Merino, or sacrifice the more essential properties of the native sheep.

The races of sheep that have been referred to may be said to be proper to, or derived from, the mountains, lower moors, commons, and chalky downs. The sheep of the lower and richer country are usually of a larger size, and all destitute of horns, and produce long wool fitted for the purpose of combing, but little adapted for felting and the production of cloth. The greater nnmber, but not all of the first named races, are termed short-woolled sheep, producing wool more or less fitted for felting. The latter races are termed long-woolled sheep, and they have been all more or less mixed in blood with the New Leicester breed. Those that may now be referred to are, the Old Lincoln breed, the Romney-marsh breed, the Cotswold breed, the Devonshire Notts, the long-woolled Irish varieties, and the New Leicester breed.

18. The Old Lincoln formed a race of coarse heavy sheep, bearing an enormous fleece of long wool. In this respect they were the most remarkable sheep in Europe. But few of the ancient race remain, nearly all having been crossed more or less by the lighter sheep of modern times. The sheep of these crosses, however, are still very weighty animals, and afford large supplies to London and other markets of consumption. They are fed in

numbers on the rich marshes of the Thames and elsewhere. They frequently weigh from 50 to 60 lb. per quarter.

19. The Romney-marsh is the term applied to the race of heavy sheep kept from time immemorial on the alluvial tract on the southern coast of Kent termed Romney-marsh. The sheep of this rich tract are large, yielding a heavy fleece of long wool. The older Romney-marsh sheep, though esteemed by the butchers, were regarded as being very defective in form; having narrow breasts, large bellies, and coarse extremities. It is long since they have been crossed by the new Leicester breed, which had the effect of diminishing their size and lessening the quantity of their wool, but of improving their general form, and giving them a better disposition to fatten. It was supposed, however, that besides the decrease of weight and deterioration of the fleece, the cross breed was less suited to the cold open pasture of the marsh. They were driven into the ditches by the strong south-westerly gales. The breeders of the Romney-marsh, therefore, now abstain from crossing, and endeavour to revert more to the characters of the original breed.

20. The Cotswold Breed, although now the inhabitants of low hills, must be classed with the sheep of the plains, from which they are manifestly derived. These sheep inhabit the calcareous tract of country which forms the eastern part of Gloucestershire. They are of massive form, and bear long wool. The older breed has been universally crossed by the New Leicester and has been lessened in size, although doubtless improved in form. But the modern Cotswold is still a race of very weighty sheep. They are hardy, prolific of lambs, and good nurses; and the lambs are early clothed with a thick fleece. They have a tendency to accumulate fat on the rump. They are nothing like so perfect in form as the New Leicester breed, but their hardiness, prolificness, and size, give them a claim to attention amongst the superior breeds of this country. The system of crossing with the New Leicesters began about 50 years ago; but for a considerable period past, the breeders have sought to preserve the breed from further intermixture, and to revert to the standard of the older race.

21. The Devonshire Notts formed a race of long-woolled sheep proper to the lower parts of Devonshire. There used to be two varieties, the Dun-faced Nott, and the Bampton Nott. They formed a clumsy race of sheep, with thick skins, bearing long close wool. They are now nearly extinct in their pure state, having been almost universally crossed by the New Leicester breed. This crossing has been singularly beneficial, the result being a race of long-woolled sheep of great size and good form. Many of the sheep of Devonshire are now to be ranked amongst the largest in the kingdom.

22. The Long-woolled Irish varieties extended, with some difference of characters, over the whole of the less elevated parts of Ireland. These sheep were of large size, had coarse heads, flat sides, and narrow chests. They have been universally crossed by the New Leicester breed, so that it is difficult to find an individual of unmixed blood in the whole country.

To these breeds might be added others which may be rather said to have once existed than to be now found. Such were the Old Warwickshire, the wool of which resembled that of the New Leicester, the Old Leicester, which has merged in the modern breed, and the Old Teeswater, which, in like manner, has had its characters entirely modified by the effects of crossing. These last were the long-woolled sheep of the district of the Tees. They were a race of very large sheep, arriving at great weight, and being very prolific of lambs. The wool produced was long and heavy to the fleece. The traces of this breed are now only to be recognised in the flocks of a few breeders, distinguished by the superior size of the animals.

23. The New Leicester is frequently termed the Dishley breed, from having been produced by Robert Bakewell of Dishley, in the county of Leicester. This gentleman was the son of a considerable farmer, and, about the year 1755, began to turn his attention to those improvements in the form of animals, by which he became so distinguished. The precise steps which he followed in the forming of his breed of sheep are not known, as he chose to observe an entire mystery on the subject, and left not a single

written memorial behind him of his curious and important experiments. But whatever were the steps which Mr Bakewell pursued, it was by breeding from animals of the form required, until he arrived at the properties aimed at in the progeny, that he gradually corrected the defects, and improved the form, of the animals. He was well aware of the external characters which indicate a disposition to fatten, and, by a steady course of selection continued during a lifetime, he obtained animals of superior fattening properties to any that had been before cultivated. By constantly breeding, too, from individuals of his own flock, and consequently near of blood to one another, he gave a permanence to the characters of his breed which it retains to the present hour. Mr Bakewell adopted the practice of letting out his rams for the season, and this contributed to the general diffusion of his breed. Successors to Mr Bakewell have continued the same system, and bestowed the utmost care in maintaining the purity of their flocks; and thus from the county of Leicester, as a centre, this breed has spread to every part of England where the breeders have thought fit to receive it. It has entirely changed the character of the greater part of the long-woolled breeds of this kingdom, and been mainly instrumental in causing that substitution of long-woolled for short-woolled sheep, which has taken place to a great extent throughout England.

The sheep of the New Leicester breed are inferior in size to the other varieties they have supplanted. The wool is only of moderate quality, and in weight it falls short of that of the larger breeds. The value of the breed, therefore, does not consist in the size of the individuals, or the quality or abundance of their wool, but in early maturity and aptitude to fatten. In these latter properties the New Leicester has not been surpassed by any other breed of cultivated sheep.

The breeds of sheep, then, of this country, may be divided into two classes,—the sheep of the mountains, lower moors, older commons, chases, and downs,—and the sheep of the plains.

The sheep of the first class have sometimes horns and sometimes want horns. The best of them have no horns, namely, the

Cheviot and the Southdown. One of them, the black-faced heath breed, has coarse wool; the others have either short clothing wool, or long but still soft wool.

Of the moorland and down breeds, as they may be called, the hardiest is the black-faced heath breed, and this property points it out as the most suitable for a high and rugged country, where artificial food cannot be procured.

The breed next to this in hardy properties, but surpassing it in the weight of the individuals, is the Cheviot. Where the pasture contains a sufficiency of grasses, this breed deserves the preference over any other known to us for a mountainous country.

The next breed meriting extensive cultivation is the Southdown. This breed is suited to a lower range of country than the Cheviot and heath sheep. To the chalky and sandy downs where it is indigenous, no breed can be better fitted, and it may be carried far beyond these limits ; but it is unsuited to the more rough and elevated pastures, to which the black-faced and Cheviot breeds are adapted.

These are the moorland and down breeds, which appear to be the most deserving of cultivation in this country. Of the larger breeds of the plains, the New Leicester is well adapted to general cultivation; and wherever an improved system of tillage is established, may be introduced.*

2. Improvement of Breeds.

The breed of sheep to be reared in any case must be selected according to the nature of the pastures, and the artificial means possessed of supplying food. If a mountain breed be selected for rearing on a low arable farm, then the advantage is lost which the farm possesses of producing a larger and finer class of animals. If, on the other hand, a lowland breed is carried to a

* For the detailed economical history of these races, see the Author's Work "On the Domesticated Animals of the British Islands."

mountain farm, an error of a different kind, but yet more hurtful, is committed; for a fine stock will be ruined if placed in circumstances where it cannot be maintained.

The breed, then, being selected which is the best suited to the circumstances in which it is to be placed, the province of the breeder is to breed from the best individuals.

Disposition to fatten, and early maturity, are the properties most regarded in sheep to be reared for food. But the property of yielding good and abundant wool is not to be disregarded; and there is another property essential in the rearing of this class of animals, namely, hardiness and sound health of the individuals.

In the case of the sheep, as of the ox, refinement in breeding may be carried too far, and with more danger. By breeding from animals near of blood, the same means exist in the case of the sheep as of the ox, of giving it that prematurity of age which produces fineness of the bones and a disposition to fatten. But it is attended, too, with the same effect of rendering the animals more delicate and subject to diseases. It seems a violence done to nature when carried too far, and the animals shew the effects of it by becoming too fine in their skins, by ceasing to produce wool in sufficient quantity, by the females ceasing to yield a sufficient quantity of milk, and by the males becoming at length unable to continue their species.

Whenever, then, the sheep of any flock become too near of blood, the breeder should resort to the best animals of another family, but of the same breed, to continue his stock. This species of crossing is now easy, since there is scarcely any of the cultivated breeds of which superior males may not be procured from other flocks. In the case of the New Leicester, so widely diffused and highly improved, no necessity can exist for breeding from animals too nearly allied.

3. Form.

In the sheep, as in other animals, certain external characters indicate a disposition to fatten, and at an early age. Other characters indicate a disposition to produce wool; and the quantity of wool, it has been said, is not to be disregarded in the rearing of the sheep. But the main purpose in rearing sheep in this country being for food, the province of the breeder is to accomplish this object with as little sacrifice as possible of the secondary qualities.

A property that indicates a tendency to fatten in the sheep as in the ox, is a general rotundity of form and fineness of the bones. The chest should be broad, the ribs well arched, and the back and loins, accordingly, broad, flat, and straight. The sheep, like the ox, occupies, when viewed in profile, and independently of the neck and head, nearly a rectangle, and the larger the proportion of this rectangle which the body occupies, the more perfect is his form as a fattening animal. His body, therefore, should be large in proportion to his limbs; his breast should be well forward, and his belly straight; his head should be small and his ears thin; his limbs to the knee and hock should be fleshy, below delicate and covered with short hair: his skin should be soft and elastic; his wool soft to the touch, thick, and coming well forward to the face, but not covering it: his face and forehead should be covered thickly with short hair, and his eyes, as indicative of health, should be lively.

4. Rearing and Feeding.

In the rearing and feeding of sheep, the system to be adopted must depend upon the nature of the farm, and the kind of stock. The treatment of mountain-sheep in an elevated country is, of necessity, very different from that of the larger sheep on an arable

farm. It is the rearing and feeding of the latter which may be first considered.

The female sheep are ready to receive the ram in October, or sooner; but the precise period is determined by the forward condition and constitution of the animals. A medium period is from the 5th to the 10th of October, in which case the ewes will begin to lamb previous to the beginning of March, and the principal period of lambing be in the early part of that month.

To prepare the ewes, they should receive good feeding for a time previous to the male being introduced; and, for this purpose, they may be turned upon the stubbles where the young grass is for a fortnight before. The ram is put into the field where the ewes are pasturing, and herds along with them. He covers them as they come into season; and one ram is considered sufficient for eighty sheep. In order to show what females have received him, and what have not, it is usual to smear his breast with pigment, which appears upon the fleeces of such ewes as he has covered; and if more than one ram is with the flock, then, by smearing the rams with different coloured pigments, as red and blue, the progeny of each is known. Such ewes as have not received the ram, may be taken from amongst the breeding-stock, and fattened for the butcher.

Rams are fit to propagate their species in the autumn of the second year. Well-fed females will receive the male even in their first year; but the proper period is in the October of the second year.

The food of sheep is herbage, upon which they feed during summer. In winter, when the pastures fail, the fattening-stock are fed on a full allowance of turnips, or other succulent food; but the ewes are suffered to pasture during the entire winter, and merely receive such an allowance of food as is required to keep them in condition. During hard frosts and snow, they may receive hay, which may be either given to them from racks, or simply spread upon the ground. They thus pasture in the fields, receiving hay when occasion requires, until within a few weeks of

the period of lambing, when they should receive an allowance of turnips, or other succulent food, laid down in the fields where they are pasturing.

When the period of lambing arrives, every vigilance is necessary on the part of the shepherd. He must be at all times at hand to assist the births. He must take his necessary rest only during the day, and for the shortest time possible, when his place can be supplied. When a house is not at hand, covered pens must be erected in the fields, and the ewes, when about to lamb, brought to the pens.

The birth of the young must be assisted, but not precipitately. The proper position of the fœtus is with its head couched upon its fore-legs. In other positions the birth is difficult, and then it generally becomes necessary to turn the fœtus, which is done by elevating the ewe from behind. Experienced shepherds are acquainted with these duties.

When the young is born, it is to be immediately recognised and licked by the dam, and assisted to the teat when necessary. When the lamb of any ewe dies, another should be supplied to her; either one of the twins of another ewe, or one that has lost its own dam. Sometimes difficulty is experienced in getting the ewe to adopt another lamb; and cases even occur, when the ewe, from some unknown cause, deserts her own young. In proportion as the ewes have lambed, they should, if possible, be transferred with their young to a field of new grass.

An operation to be performed upon the lambs is castrating the males which are not to be reserved for rams. This may be performed in a few days after the birth, generally in eight or ten days. It is done by the shepherd, with an assistant to hold the animal, and, at the same time, it is usual to cut off a portion of the tail. The operation is performed on lots of the lambs, and not on each singly as it reaches a certain age. It is well that it be performed early, the difficulty and danger increasing with the age of the animal, and that the weather at that time be dry, cloudy, and mild.

The lambs continue with the ewes, sucking them till the period

of weaning, which generally takes place by the middle of July. Weaning is simply performed by removing the young from their dams, and keeping them for a time so far asunder that they may not be disturbed by their mutual bleatings.

When the lambs are weaned, the ewes may be milked for the purpose of relieving their udders and running them dry by degrees. Three milkings will generally suffice, though, should any particular cases require more, it is the province of the shepherd to attend to them. Supposing the lambs to be weaned in the evening, the first milking may take place in the following evening, or in twenty-four hours ; the next at an interval of thirty-six hours ; the last at an interval of forty-eight hours. When the ewes are to be milked, they are driven into a narrow pen, the milkers, with pails, milking the ewes from behind ; and on each ewe being milked, she is turned round in the pen by an assistant, the milkers continuing their work until the whole are milked.

After being weaned, the lambs receive the name of hoggets, or hogs, the rams being termed tup-hogs, the castrated males, wether-hogs, the ewes, ewe-hogs.

The wether and ewe hoggets are now pastured together for the remainder of the season. When winter approaches, or rather when the pastures fail towards the end of October or beginning of November, the hoggets, male and female, are to be put on a full allowance of turnips. The turnips can either be conveyed to the ground where the animals feed, or the simpler process be adopted of penning the sheep upon the turnips.

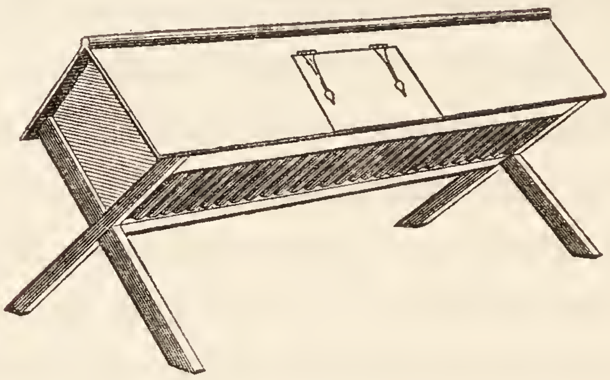
When the sheep are penned upon the turnips, they are confined to a given space, generally sufficient for them to consume in one week. The temporary fences used for penning them consist either of wooden hurdles, or nets, the latter being the most economical and convenient. In this space the sheep consume the turnips, and when they have eaten them close to the ground, the remaining portions of the roots

Fig. 209.

are picked up by means of the hoe, Fig. 209, so that the sheep may be enabled to eat them wholly up.

When they have consumed one space, the pens are shifted to another, in such a manner as to leave the ground already cleared

Fig. 210.



open to the animals for walking over and resting upon. A rack, Fig. 210, should always be placed in the field with hay.

The turnips, in place of being consumed in this manner, may be pulled up, cut into pieces by the turnip-slicer, and put into long narrow troughs. This is an approved practice. Further, besides the rack of hay, there may be placed in the field troughs containing oil-cake, corn, or other food, and a quantity of salt. The addition of oil-cake is in a peculiar manner beneficial to sheep feeding on turnips.

Sometimes when young sheep are penned on turnips till late in spring, they find difficulty, from their teeth becoming loosened, in eating the turnips when whole. In this case, the turnip-slicer should be employed.

The young sheep or hoggets are in this manner fed on turnips till the grass is ready in spring. This will be early in April, or, in the southern parts of the country, in March ; for sheep do not require the same full herbage as cattle, and may therefore be turned out at an earlier period to the fields.

Should the turnips fail before the pastures are ready, then the young sheep are to be carried on by substitutes, as hay, or even corn. It is rarely, however, necessary on a well-ordered farm to resort entirely to this costly species of feeding ; yet, when necessary, it must be done, since this inconvenience is less than the evil of suffering the stock to lose condition.

The period of shearing sheep depends upon the forward condition of the animals. When fat, the old wool begins to come off more early than when they are less forward. Good-conditioned sheep may be shorn in May, but always early in June; the precise period being denoted by the state of the wool, which comes readily off when plucked, and which would fall entirely off were it not shorn.

About eight days previous to shearing, the sheep are driven to a pool, if possible in a running stream, and three or more persons are to stand in this pool. The sheep are brought forward to a pen on the bank, and lifted into the pool one by one. The first of the persons in the pool seizes the sheep by the wool, and keeping it on its back, plunges it well from side to side. He passes it on to the person next in order, and he in like manner plunges the animal in every direction. This person then passes it on to the third, who examines the fleece as well as circumstances will allow, plunging the sheep at the same time, and thus finishing the operation. The animal is thus passed through the hands of three persons, and sometimes more; but the last should be a trusty person, such as the shepherd himself, whose duty it is to see that the fleece is completely washed and freed of sand and impurities.

This description has a reference to young sheep or hoggets, whose management we are now considering; but the same method is applicable to all the sheep upon the farm, young and old, with this difference, that the ewes, which are at this period suckling their young, have the lambs separated from them during the process of washing.

The sheep being washed, are driven to a clean pasture, and when the fleece is dry, which it will be in a few days, if the weather is good, the sheep may be shorn; but it is generally thought better that seven or eight days should elapse before shearing them, in which case the yolk of the wool is renewed.

When the sheep are to be shorn, they are driven to a pen or other enclosed space, and brought one by one to the shearers.

The sheep to be shorn is first placed upon its rump, and the shearer, with the shears (Fig. 211), beginning at the neck, clips in a circular direction down the belly towards the back. The animal is then laid on its side, and kept down by the leg of the shearer, who clips the fleece all round to the back. Turning the animal on the other side, he clips in like manner round to the back; and raising the sheep, he clips the part of the fleece not yet cut away, and so lets the animal go, taking care that it shall not entangle itself with the fleece. The fleece, as soon as it is shorn, is taken away by an attendant, spread out, neatly rolled up with the inner surface outmost, and then deposited in some dry place, until it is packed in the wool sheets.

Fig. 211.

When the animals are shorn, they are frequently marked with a stamp (Fig. 212), dipped in boiling tar, to distinguish the kinds and ages of the sheep. This kind of mark, though convenient, is injurious to the wool.

Fig. 212.

After the operation of clipping, the young sheep are termed shearling sheep; the castrated males, shearling wethers; the females, shearling ewes; the rams, shearling tups or rams. But it is common in some districts to apply to them at this period the following terms:—The shearling wethers are termed dinmonts; the females are termed gimmers; and the rams are still termed shearling rams; and these names the animals retain until they are shorn of their second fleece in the following year.

The shearling ewes or gimmers are, after being shorn, kept at grass for the remainder of the season, and they receive the rams in October in the manner described.

The shearling wethers or dinmonts are, soon after shearing, fit for the butcher. They are then about one year and three months old. If of the Leicester breed, they will weigh 16 lb. or 18 lb. the quarter, and their fleeces will yield 7 lb. each, or more.

But should the pasture be inferior, the breed bad, or the stock not in sufficient order, or should the state of the markets render

it inexpedient to sell, then the shearling wethers may be kept upon the farm for one winter more. In this case they are pastured precisely as when they were hoggets during the remainder of the season; and when in autumn the pastures again fail, they are penned on turnips, and treated in the same manner as in the previous winter.

The shearling wethers or dinmonts are frequently sold fat before they have completed the entire winter's feeding. But it is more common to keep them during the winter on turnips, to put them upon good and early grass in spring, and to dispose of them after they are shorn. They are then two years and two or three months old, and have yielded two fleeces to the breeder. They will weigh at this age from 25 lb. to 30 lb. the quarter or more, and their fleeces will weigh about 8 lb.

These and other sheep, after they are shorn of their second fleece, are termed two-shear sheep: the males not castrated are simply tups or rams; the males castrated are wethers, and the females are ewes. It is more profitable to be able to feed off sheep when shearlings, than to retain them till they are two years old. The former is the perfection of feeding; but it is a perfection attainable on every arable farm in this country on which turnips can be raised, and a superior breed of sheep maintained.

In the practice of the farm, then, the male sheep are disposed of either after having yielded one fleece, or after having yielded two fleeces. Such of the ewes as are reared on the farm, but are not to be employed for breeding, may be treated in the same manner.

But with respect to the ewes upon the farm kept for breeding, it is necessary, after they have borne lambs for several years, to dispose of them, and to supply their place by younger ewes reared upon the farm. A certain number of shearling ewes or gimmers being each year added to the breeding stock, an equal number of the oldest ewes are disposed of, and thus the number of breeding sheep is maintained.

And not only are all ewes which have borne the required number of lambs to be disposed of in this manner, but also all breeding

sheep, of whatever age, that are not healthy, or that are of a defective form, and their place is to be supplied by the younger and better stock reared upon the ground.

These, then, have been the principal points of practice in the management of a sheep-stock reared upon the farm: The female stock, like the males, were suckled by the dams till July; they were then weaned, and pastured with the wether-hoggets during the remainder of the season, when they were put together with the latter on turnips before winter; they were fed on turnips till April, when they were turned out to pasture along with the wether-hoggets; early in June they were clipt; in the month of October they were joined to the rest of the ewe stock, supplying the place of the older ewes that had been disposed of; and after this time they were treated in all respects as breeding ewes, and kept upon the farm till they had borne lambs for three or four years. The males, it has been seen, were castrated a few days after birth,—were weaned in July, when they received the name of wether-hoggets,—were pastured during the remainder of the season, and were then, together with the ewe-hoggets, penned on turnips; in the following April they were put on grass, and by the beginning of June they were washed and clipt; they then received the name of shearling wethers or dinmonts, when they were fat, and ready to be sold as soon afterwards as convenient: Or, when, from the deficiency of feeding or other cause, they were not then ready for the butcher, they were again pastured during the summer, and a second time penned on turnips, and generally pastured till they were clipt a second time, when they were two-shear wethers, and in high perfection with regard to growth and fatness.

Sheep, especially when fat and loaded with wool, are often unable to rise when they have fallen upon their backs in any hollow place, and they will perish if not relieved in time. To guard against these and all other accidents, sheep must be regularly tended. They must be examined at least twice in the day; they are to be cleaned when necessary, by cutting off clotted wool, and above all things they are to be guarded against the attacks of

maggots. In the latter case, a decoction of tobacco mixed with spirits of tar, and in some cases a solution of sublimate of mercury, are the remedies commonly employed. Their heads are frequently injured by the attacks of flies; for which a little tar spread upon the wound is the most common and the best remedy.

In the whole treatment of sheep, gentleness is of great moment. The worrying and harassing of them by dogs is never to be thought of. In upland pastures the faithful dog is essential to the shepherd; in an enclosed country the necessity for employing him is greatly lessened, and he is always to be used with temperance and humanity towards the flock.

The treatment of a lowland stock has been described, where the breeder is likewise the feeder; but sometimes the purpose of the breeder is not to fatten the stock which he rears, but, after having brought it to a certain age, to dispose of it to others who fatten it. Sometimes, on the other hand, the design of the farmer is not to breed sheep, but to buy them from others whose interest it has been to rear and not to fatten them. The effecting of these sales, on the one hand, and the making of these purchases on the other, constitute one of the branches of farming as a business. But it is a branch that cannot be taught by rule, but must be learned by practice.

One of the branches of sheep-farming, in which the breeder is likewise the fattener, is the rearing of lambs and selling them when fattened. The lambs are fattened by the milk of the mothers, and are merely disposed of when they are ready for being killed. The feeding of the lambs in the house for early consumption is also practised, and in some parts has been brought to a system. This branch of management need not be described. The sheep of the Dorset breed are valued as being the best suited to yield early lambs in this manner.

Grass in summer and turnips in winter, with a little hay for the ewes, have been spoken of as the essential food of sheep. The basis of this system is the turnip crop. But, in certain cases, this mean of support may fail or be wanting, and it then becomes necessary to resort to other substances. Potatoes, mangel-

wurzel, and other roots, may be eaten by sheep as well as by oxen ; and cabbages and rape are perfectly suited to the purpose of feeding them.

All kinds of farinaceous food are consumed by sheep. When corn is given, it is a common practice to lay down the sheaves unthrashed, when the sheep readily separate the grains from the straw ; but it is more correct management to place the corn in troughs.

Brewers' and distillers' grains may be given to sheep ; and they will consume this nourishing substance readily. Oil-cake, too, is well calculated to fatten sheep, and may be used either along with turnips, or even along with hay, where cheaper methods of carrying on the stock are wanting.

Attempts have sometimes been made to soil sheep during summer, in the same manner as horses and oxen. This practice is common on the Continent, where the sheep are kept in pens and littered ; but it has made no progress, nor is it likely to make much progess, in England, so much more simple and economical is the turning out of the animals to pasture in the fields. Yet it is certain that there are cases in which sheep may be soiled without detriment to the animals, and with a large acquisition of useful manure.

Besides common food, there is the condiment, Salt, of great importance to sheep, as to all domestic animals, but which is too much neglected in the rural economy of this country. If laid in troughs, or even on flat stones, the animals will quickly find their way to it, and will be seen to wait for their daily portion of salt with as much eagerness as for their periodical supply of food.

I have spoken of the management of a lowland breed of sheep. It is necessary to consider also the treatment of the animal under circumstances entirely different ; that is, when reared and pastured in a country where cultivated food is either wanting or to be procured in limited quantity.

The Cheviot sheep are reared in an elevated country. But in the places where they are produced, turnips and the cultivated grasses may generally be supplied in certain quantity.

In the rearing of this breed, the rams are usually put to the ewes from the middle to the 20th of November, so that the lambs shall begin to drop about the first of April. The ewes generally receive no further feeding during the period of gestation than hay in falls of snow. This may be supplied to them from racks, or simply laid upon the surface of the snow. The ground is frequently covered with snow for six weeks; but it is sometimes covered for twice that period. During the winter, therefore, a store of hay should be in reserve for three months' consumption, and this may be calculated at the rate of $1\frac{1}{2}$ lb. per day for the ewes and older sheep, and 1 lb. per day for the younger sheep. Should the winter be mild, what is left remains till the following season.

When turnips are raised, these are given also to the breeding stock. The ewes receive them during falls of snow, and in an especial degree when the lambing season arrives, and during its continuance.

When both hay and turnips are to be supplied, it will be proper either to give them at the same time, that is, a portion of hay and a portion of turnips each day, or to begin with hay and end with turnips; for to begin with turnips and end with hay is to cause the sheep to pass from succulent food to one which is less grateful, so that a time elapses before the animals are reconciled to the change. But when turnips are given, and hay supplied at the same time, the sheep take to this variety of feeding very readily.

The process of lambing in these high districts demands the utmost vigilance of the shepherds. They must never be absent night or day, but relieve one another, and inspect the flock at short intervals, so as to assist the parturition of the ewes when necessary.

Sometimes the lambs at their birth are so weak that they cannot rise to the teat, and thus perish or are forsaken by the dams. The shepherd assists them in such cases, and frequently takes the ewe with her young to a house or place of shelter, where they can be attended to. When the ewes have twins, and thus

have two lambs to nurse, it is usual to give them a more liberal supply of food. For this purpose it is convenient to have an enclosure of early grass near the place of lambing, or the shepherd's cottage, to which ewes with twins, such as have too little milk, and such as are sick and infirm, or from any cause require more attendance than the rest of the flock, may be taken. Though various ewes produce twins, it is regarded as a favourable circumstance in the case of this class of sheep when one lamb can be reared for each ewe of the flock. It is well when nineteen lambs can be reared for every twenty ewes.

As soon as the weather is favourable, after a considerable number of the ewes have lambs, they are collected into a fold, and all the males castrated, except such as are reserved for rams; and the sooner the operation is performed after the lambs are a few days old the better.

When the period of shearing arrives, which is known by the wool being fully grown, the sheep are washed, sometimes by men standing in the pool, who wash each sheep separately, in the manner before described; or, when the flocks are large, by causing them to swim two or three times through the water to the opposite bank. After being washed, they are kept as much as possible on ground where they can be prevented from rubbing on banks, or otherwise soiling their wool. In two days, if there be no rain, they may be shorn, but it is generally thought better to wait seven or eight days. The wool is shorn in the manner before described, and stored in a proper place till packed in sheets. As soon as each sheep is shorn, it may be marked with a stamp dipped in boiling tar. The mark is made on different parts of the body, as the near shoulder, the far shoulder, the near rib, the far rib, so as that the different kinds and ages of the sheep can be known at a glance.

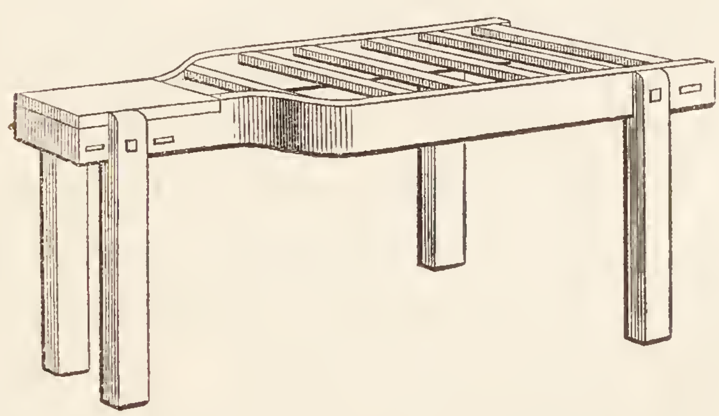
About the middle of July, the lambs are weaned, when such lambs as are to be disposed of are separated from the remainder and sold. The lambs, now hoggets, are put on such good pasturage as the farm affords, and supplied, if possible, with turnips

throughout the winter, at the rate of a cart-load for seven or eight scores in the day.

Some farmers still milk their ewes for a few weeks; but the more approved practice is to milk them only for a few days, merely to relieve the ewes of their milk by degrees.

Before winter, it is a general practice, the utility of which is experienced in a very elevated country, to smear the skins of the sheep with a mixture of tar and butter. The practice, indeed, is found to deteriorate the wool, by staining it, and rendering it unfit for receiving the brighter colours in dyeing. It is found, however, conducive to the health of the stock in an inclement country, destroying vermin, of itself an important object to the health of the sheep, and acting to a considerable degree in defending the animals from cold and moisture. The mixture is prepared by boiling the butter, and mixing it with the tar, and sometimes by adding some milk; the proportions employed differing according to the practice of different farms and districts. In some places 6 lb. of butter to one gallon of tar are considered sufficient for twenty sheep. The period of smearing is the end of October or beginning of November, that is, before the rams are admitted to the ewes. The method is, to place the animal upon a stool, Fig. 213, to separate the wool, and with the end of the

Fig. 213.



finger to smear the skin longitudinally from head to tail. One man will smear from 20 to 25 sheep in a day. Substitutes are now very generally used for tar, which, though not so efficient, are less hurtful to the wool.

It is a general error on merely stock farms to plough up too much of the land for crop, or to intersperse the cultivated land with the range of the sheep-pasture. The object of tillage on such farms is to raise turnips and clover-hay, for keeping the stock throughout the winter months, and this being attained, the farmer ought rarely to carry his system of tillage further.

In many cases, indeed, the farmer of a mountain farm has also a sufficient quantity of lowland ground to allow him to continue the practice both of rearing sheep and fattening them. This, when it occurs, is beneficial; but when it does not occur, the proper occupation of a mountain farm is to rear sheep, and not to fatten them; and the general principle of management is to sell the sheep which are reared to the grazier as soon as they have come to tolerable maturity, that is, even after the first winter, when hoggets, or after the second winter, when shearlings.

Reared in yet more elevated districts than the Cheviot, are the Black-faced heath sheep. These are amongst the hardiest of all our races of sheep, and in the parts of the country where they are principally cultivated, they must depend chiefly or entirely on the natural herbage of the farm.

The rams are generally put to the ewes after the middle of November, and one ram is assigned to sixty ewes or less. The lambs intended for wethers are castrated somewhat later than the other sheep: they are weaned late in July, and the ewes milked sometimes for a few weeks. The sheep are shorn from the end of June to the middle of July; and when they are to be washed, they are driven to a pool or deep stream, and forced to leap from the bank. This being a very wild race of sheep, the same delicacy of management is not necessary or practicable as in the case of the more docile breeds of the plains. They are shorn in the same manner as the other sheep; and opportunity is then taken to place upon them their distinguishing marks. In all cases they should be smeared; for though, as in the case of the Cheviot sheep, the wool is injured by the process, this is more than compensated by the benefits resulting to the flock.

The food of these hardy sheep is in summer and winter the

same; and all that can be generally done is to supply them with some hay during long-continued falls of snow. They are sold at the ages which suit the nature of the farm and the convenience of the breeder.

The management of the other kinds of down or moorland sheep need not be detailed. These breeds are generally in low situations, where the difficulty of procuring food is comparatively little. The nearer the management of this class of sheep approaches to that of the larger sheep of the plains, already described, the more perfect will it be.

5. Diseases of Sheep.

The diseases of these valuable creatures are sometimes of a very formidable nature, and baffle all the means of remedy which are known to us. Of these diseases the most dreaded is *rot*, which often extends over whole districts of a country.

It is known that this disease is favoured, or produced, by a humid state of the soil and atmosphere. It is in wet seasons that it prevails the most, and is the most fatal. By draining land the tendency to it is lessened or taken away. Often sheep are rotted by pasturing on the wet parts of the farm, whereas if kept from these parts they remain free from disease. Nay, a single sheep that has a disposition to pick up its food in moist places will die, while the others will not be affected.

The animal affected does not all at once show symptoms of disease; for sometimes it remains a considerable time in apparent health, and long after it has been removed from the place of infection, droops and dies. Sheep are every year purchased in seeming health, and yet after a time they are found to be affected. A moist and even luxuriant autumn is dreaded above all things by the owners of sheep; for the seeds of infection are then often spread, to appear in the following spring, or after the lapse of a longer period.

The signs of rottenness in sheep are familiar to all shepherds. The animal becomes emaciated, its eye becomes dull and glassy, a black purging generally takes place, the wool, on being pulled, comes readily away from the skin, the breath becomes fetid, and the urine is small in quantity and high coloured. As the disease proceeds, the skin is marked with spots, and the emaciation increases continually, until the sheep dies. In short, the term rot expresses truly the state of the animal. The disease proceeds with various degrees of rapidity: sometimes it attacks the entire flock suddenly, and sometimes its progress is gradual, and it affects only a given number of individuals. Graziers often avail themselves of the period of the animals beginning to decline to rid themselves of an infected stock. During the first period of being tainted, the sheep have frequently a strong tendency to fatten, and if killed in time the flesh may not be perceptibly affected.

In all cases of rot the disease is accompanied by a morbid state of the liver. During the progress of it, the fluke, a small animal, *Fasciola hepatica*, appears on the parts connected with the liver and the gall-bladder. At first the number of these creatures is small, but as the disease advances they increase, and before death are generally very numerous. In the last stage of the disease they have extended to the stomach and other parts.

Frequently the disease terminates favourably, the inflammatory action going off without destroying the parts. But even in this case, the taint is rarely removed, and years afterwards, when the animal has been fattened and killed, the liver has been found to be diseased, the flukes being in great numbers.

The best preventive of rot is to render the soil dry; and hence on all sheep pastures the importance of draining. But should the disease, in spite of all precautions, appear, then we should, without loss of time, remove the sheep to a drier pasture, and supply them liberally with proper food. It is only, however, in the early stages of the disease, that a change of food will usually avail. If the disease has proceeded to a considerable extent, even though it should not have evinced itself by any great change in the external

appearance of the flock, the animals will often perish hourly amidst the most wholesome food with which they can be supplied.

Of all the medicines that have been proposed for this fatal disease, salt alone is that whose virtue has been established by any satisfactory testimony. The beneficial effect of salt in the prevention and even cure of rot has been confirmed by the observation of farmers in this and other countries.

Salt, indeed, will not in all cases prevent or cure the disease; for sometimes the tendency to it from particular causes is too strong to be counteracted, and, when it has once attacked the flock, too violent in its progress to be arrested. But though salt is not a specific, it is the best means of remedy with which we are acquainted.

If salt be placed near the animals in troughs or on flat stones, they will eagerly lick it, and when disease threatens them, it may be given to them in any quantity in which they will consume it; for it is then seen that they are obeying a natural instinct in having recourse to the remedy; and in a wet season, when disease may be apprehended, no one should grudge the trouble of so cheap and simple a precaution.

Much has been written npon the subject of this disease, but all that has been written has nearly left us where we were with regard to the remedy. It had been long known that wetness of the soil, however produced, gave rise to rot; that the best preventive was pasturing on dry ground, and giving sufficient food; and that the best remedy where disease appeared was a change of pasture. To these results of old experience is to be added, the using of salt.

Another disease, arising from a different cause than the rot, but like it ending in emaciation, and the death of the animal, is provincially termed *pining*. This disease is accompanied by a costive state of the animal, whereas the rot is never accompanied by costiveness; and in the rot the liver is always affected, while in the pining the liver is sound.

This disease seems to arise from the want of exercise, and from the animals feeding on very dry pastures. Before the ex-

tensive draining of the pasture-lands, where it is now found, the disease was unknown. The rot was then common; but with the draining of the lands the rot disappeared, and this new disease took its place. The former practice of management in the districts where the disease now prevails was to keep the sheep in flocks, which were moved about along their allotted range of pastures. They are now, under a more approved system of management, suffered to spread over a large extent of pasture; and thus they are not obliged to take exercise, but are allowed to feed more on a given spot of ground.

A change of place and food is the preventive or the remedy; and if a change of food is resorted to in time, it is generally sufficient to arrest the progress of the disease. Even a removal to a fresh heath will sometimes accomplish the purpose, but the proper and effectual remedy in all cases is a change to a more rich and succulent pasture. The disease is sometimes very fatal, destroying entire flocks like a pestilence.

Sheep are subject to a long and frightful train of inflammatory diseases. In all such cases, however they may affect the animals, bleeding should be at once resorted to, as the only mean of subduing the disease, and giving a chance of safety. The eye-vein is that usually opened in bleeding the sheep; but all shepherds should be taught to bleed from the jugular vein, as being the most suitable. The quantity of blood extracted must vary with the age and strength of the animals. The rule in the case of the sheep, as in that of the ox, is to bleed freely. Purgative medicines, too, ought to be given to the sheep, in the case of this class of diseases, and of them the most approved are, Epsom salt, in the proportion of from 4 to 6 oz., and about half that quantity, or a little more, of Glauber's salt. Common salt is often applied in country practice with the effect desired. On the part of shepherds, it is to be observed, there exists a prejudice against the administration of medicines to sheep, doubtless from their having observed the little effect usually produced. But this prejudice should not be permitted to operate where the lives of sheep are in imminent hazard, as is the case in all inflammatory dis-

cases. It is beyond a doubt, that, by prompt bleeding, and the judicious administration of purgatives, the lives of many thousands of these valuable creatures may be yearly saved to the country.

Amongst the inflammatory putrid fevers to which sheep are subject, one, termed braxy, is very destructive in various parts of the country. The progress of this disease is very sudden and violent. Of the remedies to be employed, bleeding and purging are plainly those which the nature of the disease points out. This disease seems generally to be caused by bad food, and the most efficient preventive is known to be good feeding. Turnips or other succulent roots given to young sheep feeding on natural pastures are always beneficial; and it is to be observed, that, in proportion as the treatment of sheep in the country has improved, this dangerous malady has diminished.

Diarrhœa and dysentery are diseases of sheep. Diarrhœa is frequently produced by too sudden a growth of grass in spring, and it most frequently affects young sheep. It may be generally cured by removing the animals to drier pasture; and a little corn may be always given with good effects.

Dysentery is a more serious disease, and is often very destructive. In this disease, bleeding is plainly required to subdue the inflammation, and purging to carry off the peccant matter in the intestines. Hay may be offered and a few sheaves of corn laid down, and the use of mashes will in an especial manner be found beneficial.

Sheep are liable to various cutaneous diseases. The principal of these is termed scab; and it is indicated by extreme itching and eruptions of the skin. When introduced into a flock it may be attended with very serious effects, unless checked by efficient remedies.

The most common remedy for the disease is sulphur mixed with some unctuous substance to fix it on the skin. One of the best receipts perhaps is a decoction of tobacco and spirit of turpentine, with the addition of a little soft soap and sulphur vivum. The decoction of tobacco may be obtained by boiling the tobacco

in brine or salt water. The liquid, when prepared, is applied from a vessel like a teapot with a spout, or from a bottle with a quill passed through the cork. A person lays the wool back in lines so as to expose the skin, and pours out the liquid along the lines upon the skin. But when the distemper is very violent, a mercurial preparation may be required. This is now to be obtained in apothecaries' shops under the name of sheep-ointment. It is made into balls, and when used is dissolved in oil, and applied to the skin of the animal.

Sometimes infected sheep will find their way into the best managed flocks; but every care must be taken to keep the disease from breaking out, or to cure it as quickly as possible when it appears. The infection of a diseased flock is left behind it upon the hedges and pasture-fields, and therefore precaution is to be used before a fresh flock is turned into fields where infected sheep had been recently feeding.

Another disease of sheep is the foot-rot, which is an inflammation of the foot, followed by an ulceration and destruction of the hoof. This disease chiefly prevails in wet seasons, or in soft grounds. It is a very painful disease, causing the entire lameness and loss of condition of the animal. Certain grounds are noted for communicating the foot-rot; and as it appears amongst the pasturing stock season after season, such grounds are popularly said to be infected with the foot-rot. But the cause may be reasonably ascribed to the accumulation of undecomposed vegetable matter on the surface.

Although painful and destructive to the good condition of the animal, this disease is not absolutely fatal, except under entire neglect, in which case the animal becomes unable to seek his food, crawls upon his knees, and, worn away by exhaustion, perishes. But if early attention be paid, the disease admits of remedy. In the first place, let all the affected part of the hoof be pared away, and the ulcerous matter removed, and then let the foot be washed with soap and hot water, and let the surface be dressed with some caustic, of which the best is muriate of antimony. In incipient cases, by simply paring the hoof, and cleansing it with soap and

water, and then dipping it in boiled tar, the progress of the disease will be arrested.

The next disease to be mentioned is of frequent occurrence. This is hydatids, staggers, or water-in-the-head as it is sometimes termed. The cause of this disease is a parasitic animal, a hydatid, which is found in the brain of sheep. It enlarges in size, and, if not removed, ultimately destroys the animal. This creature, when distended with fluid, resembles a round sac filled with water, and hence it was long supposed to be water, and the disease, in consequence, termed water-in-the-head.

When the hydatid is in the brain, the animal affected shows great symptoms of distress; he leans his head to one side, mopes by himself, continues turning round, and finally dies. The remedy for this disease is to reach the hydatid, and to extract it, or at least to perforate it in such a manner as to destroy its vitality. When it is situated at the surface of the brain, the part feels soft, and it may be reached by a sharp instrument, as a common awl or gimlet, or the hydatid itself may be extracted. This may be done by the trephine. Shepherds perform the operation in a rude manner by a sharp knife. A small portion of the skull is so cut as to be raised up like a lid. The hydatid being exposed, is pulled out by pincers, and the fluid absorbed by a sponge or piece of linen. The skull is then replaced, and dressed with common tar put upon a piece of soft leather.

Often the hydatid may be reached by a wire thrust up the nostrils, and it is remarkable that this operation frequently succeeds in the hands of shepherds.

Sheep are liable to the attacks of various animals. One of these, a species of aphis, termed the sheep-louse, is very common, and chiefly prevails where the sheep are in an unhealthy condition. It is of a flat form, and, attaching itself to the throat and other parts, occasions much irritation. Tar, turpentine, or tobacco liquor, are the substances chiefly used to destroy this animal, and any simple mercurial preparation is effectual.

But the most pernicious enemy that attacks sheep, is the common sheep-maggot, the larva of a species of flesh-fly. The fly

having deposited her eggs on the skin of the sheep, the larvæ are hatched in great numbers, and grow with amazing quickness. They commonly appear about the root of the tail, or wherever filth has allowed the fly to attach her eggs, and thence they spread over the entire body, consuming the skin, and eating into the flesh. The sheep, when attacked, manifest a strong sense of suffering. They frequently run with violence, until at length, overpowered and exhausted, they lie down and perish.

It is in moist and warm seasons of the year that the sheep-maggot is chiefly produced. Constant vigilance is then demanded on the part of the shepherd, so that all foulness of the wool shall be clipt away; and the sheep must be daily inspected, lest this dangerous enemy establish itself. The maggot is effectually destroyed by a solution of corrosive sublimate, and in its early stages by less potent applications, as by urine and lime.

We must remember that the sheep, in his domesticated state, is yielded up to the care of man; his natural instincts are blunted, and he is unfitted for those means of preservation which in his wild state he might possess. He is the prey of a multitude of enemies, against which he has no defence; and the more artificial his condition is, the more is he dependent on our care.

6. Wool.

Hair is an appendage of the skin of the mammalia. It consists of fine filaments growing from beneath the skin, to which it serves as a covering; it is nearly the same in its chemical composition as horn and feathers; it is kept flexible and moist by an oily secretion from the skin; it is furnished with bloodvessels, like all the other organs of animals. Being intended chiefly as a covering to the animal, it abounds the most under those circumstances where it is most required. Quadrupeds are more or less covered with it, and for the most part in the greatest degree where the cold is the greatest. Man is slightly supplied with

this universal defence; but he is enabled, by his reason, to adapt the hair of other animals to his use.

When the hair of animals is very thick and strong, it forms spines and bristles; when more fine, it forms hair, commonly so called; when it is fine, and at the same time curled, it is termed wool. It is this curling property of the wool which renders it more suitable than any other species of hair for being woven into cloth. The fur of animals consists of a mixture of hair and wool, but the latter is often in very small quantity. The wool principally used for the purpose of forming cloths is that of the domestic sheep; and we know that this substance has been so employed from the earliest records of the human race. But the wool of various other animals is applied to the same purpose, as of the camel, the lama, and the goat.

Wool frequently loses its curling property, and passes into hair. In the warmer regions the fur of sheep is more hairy than in the colder, apparently because a less thick and matted covering is required for the protection of the animals. Hair also is found, and sometimes in large quantity, intermixed with the wool of sheep in cold and temperate countries. This intermixture of hair unfits the wool for many manufactures, and it is a process of art to separate it from the wool. By neglect in the treatment of the animal, the proportion of hair increases; by care and more complete domestication, the quantity of hair diminishes.

The wool of sheep, like the hair of other animals, is periodically renewed, the older hair falling off, and a new growth taking its place. In the case of the sheep, this renewal of the wool usually occurs once in the year, and at the beginning of the warm season. It is at this period that we anticipate the natural process by shearing or cutting off the external part of the fleece. In some countries the fleece is not shorn, but is pulled off: and in certain conditions of climate and the animal, the wool remains for more than one year. This is especially observed in the Merino race. The manner in which the wool is renewed seems to be by a fresh growth from the same roots, and by the old portion breaking off.

Wool, like every kind of hair, grows quickly when cut. We may shear our sheep, therefore, more than once in the year, and the wool will grow again. But, in this country, it is never thought expedient to shear the wool more than once in the year, and the proper period is always when the old fleece is about to fall off, that is, at the beginning of summer. The precise time is somewhat dependent on the condition of the animal. When fat, the wool tends to fall off more early than when the animal is lean. Frequently disease, and especially disease of the skin, causes the animal to lose his fleece.

The wool of lambs is sometimes shorn, but this is a practice not to be followed in a cold climate. The sheep of this country ought never to be shorn until the second year of their age.

The wool of sheep is sometimes black or brown, and the wool of all the less cultivated animals tends more or less to a dark colour. Some of our sheep, even of superior breeds, have black faces and legs, as the Southdown; and, in all these breeds, there is a tendency to a mixture of black wool with the white. This is an imperfection in the wool, the black piles not being fitted to receive the dyeing colours.

From notices in ancient writers, there is reason to believe that the former colour of sheep was more frequently black or brown than it now is. But if the least attention were paid to the choice of rams, it is easy to suppose that the white colour would ultimately prevail in the domestic sheep of almost all countries; and, from the earliest times, it would be known that black wool was not fitted to receive those beautiful colours which so much please the taste even of the rudest nations. But, in this country, although we have frequently sheep bearing black wool, there is no inducement to propagate the peculiarity in the race, and hence black rams are never used.

Wools are distinguished from one another by the length, which is termed the staple of the wool, and by the fineness of the pile or filaments.

In this country, the length or staple of the wool is an important distinction, because it is this which, in a great measure,

fits it for a certain manufacture. When the wool exceeds 3 inches in length, it is termed long wool; when it falls short of 3 inches, it is termed short wool. The long wool is chiefly applied to the manufacture of worsteds; the short wool to that of woollen cloths. These two kinds of wool are also distinguished by the peculiar manner in which they are prepared for being spun into thread.

The long wool, which is employed for the fabrication of worsteds and other fabrics, is passed in a peculiar manner through combs, with fine steel teeth. The design in this process is to assort and lay together the filaments of the wool somewhat in the same manner as in the case of flax, previous to the process of spinning. That wool may be suited to this operation, it must have a considerable degree of length as well as of strength of pile, so that it shall not be broken when passed between the teeth of the comb. It is the long and stronger wools that are usually treated in this manner, and hence the long wools of this country are familiarly termed *combing* wools.

The wools, on the other hand, intended for the manufacture of woollen cloths, undergo an entirely different preparation previously to being spun. They are not kept entire and assorted in lengths, but are broken into minute pieces, and mingled together in every direction. This is done by the operation of what is called *carding*.

Upon a board, let it be supposed, with a handle attached, is fixed a great number of crooked wires or teeth bent in one direction. These are partially filled with wool. Another board or card of a similar kind is then pulled, so that its teeth shall pass through amongst the teeth of the other; and, by the repeated action of these two cards, the wool is broken into minute pieces, which, from the crisping or curling property of the wool, hook themselves together, and, by a peculiar art, are formed into long rolls, or rovels as they are technically called. These rovels, consisting thus of the minute and broken parts of the wool hooked together, are in a state to be spun, and may be said to form the rudimental thread. This is the process termed carding, which on

the great scale is performed by machinery; and the short and more delicate wools being suited to this process, they are accordingly termed *carding* wools.

We have thus two classes of wool; the long wool, also termed combing-wool, used for the manufacture of worsteds; and the short wool, also termed carding-wool, used for the manufacture of cloths.

But, by improvements recently made in the machinery for the woollen manufacture, wool that was formerly deemed only suited for carding, may now be prepared by the comb. Thus, the South-down wool, which was entirely appropriated to the card, is now likewise prepared by the comb, and consequently may be employed for a different class of fabrics. On this account, short wool is not now entirely synonymous with carding-wool, although it may be always prepared by that means.

Wool, subjected to the carding process, ought to possess certain qualities. 1*st*, It ought to have that peculiar crisping or curling quality which distinguishes wool from hair, so that when broken into minute pieces, each part may curl at its extremities, and all the parts be hooked together, and form what has been termed the rovelling; 2*d*, It ought to be free from hairs, for these, not possessing the curling property, will not amalgamate with the other parts, and so will injure the future fabric.

Wool ought to be soft to the touch and pliable; the filament, too, ought to be regular, that is, it ought to be cylindrical, or rather a scarcely perceptible cone from the root to the extremity. Further, it ought to have that peculiar property to which the term felting has been applied.

This latter property consists in a tendency in the filaments to unite or adhere when pressed together. We avail ourselves of this property of hair in the manufacture of hats, which are formed of the wool and down of animals. By pressure and moisture, all the parts adhere so closely as to become a compact mass. The same property is applied in the manufacture of cloth, by pressure and moisture, after the cloth is woven, by which means the filaments and threads contract, adhere closely together, and do not

unravel when cut. This is a property of great estimation in woollen cloth, and certain wools possess more or less of this property of felting, or cohering together.

Woollen threads after being woven into cloths, are subjected to the action of the fulling-mill. The use of this operation, which consists in beating the cloth in water, along with clay, is to free it from the oily matter with which it is mixed. It serves, however, the further purpose of felting the woollen substances, which contract under the operation.

The process of felting seems to depend upon the peculiar structure of the filament, from which proceed innumerable minute laminæ all round. Though important and necessary in the case of woollen cloths, the property of felting is not so in the case of certain worsted fabrics, as flannel. It is not then desired that the fabric shall contract and cohere like cloth, but that it shall maintain a certain openness of texture; and the wool is more or less deprived of its felting property in the combing process.*

The properties to be chiefly regarded in wool, then, are,—

1. The length of the pile, or filaments, which chiefly determines the peculiar species of manufacture to which it is appropriated: 2. The curling or crisping property: 3. The softness of the wool; with respect to which it is to be observed, that certain soils seem to communicate a greater or less degree of hardness to the filaments. The Saxon wools are noted for the property of softness; in a peculiar degree the Australian; and,

* Mr Youatt, in his Treatises on the Domestic Animals, contained in the Library of Useful Knowledge, has shewn that wool is beautifully serrated, the serratures rising from the filament in tiers of minute scales all round, somewhat resembling leaves. Mr Youatt has further very clearly shewn, that the felting property of wool has a constant relation to the number and form of these laminæ. Thus, on comparing a fibre of the Merino wool of Saxony with that of the Southdown, he found that the former, which is far superior in fineness and felting properties to the latter, was $\frac{1}{840}$ of an inch in diameter, and contained 2720 serratures in the space of an inch; while the Southdown fibre was $\frac{1}{660}$ part of an inch in diameter, and contained only 2080 serratures in an inch; and further, that the serratures of the Southdown wool were rounder and less acute than those of the Saxon; and numerous other examples equally conclusive are given of the relation existing between the number and form of the serratures, and the felting properties of the wool.

amongst the native wools, the Zetland: 4. The pliability of the filament: 5. The regularity of the filaments, and the absence of hairs: 6. The peculiar property termed felting.

Not only are fleeces thus different in the quality of their wool, but each fleece contains wool of different qualities with respect to fineness. It is the separating of these different sorts from one another that constitutes the process of *stapling.*

The stapler divides the wool of the fleece into nine, ten, or more different sorts, to each of which he gives appropriate names. The operative part of this process is one of nicety, and to which men are trained, as to the other mechanical arts, by a careful apprenticeship. In this country, the stapling or assorting of wool is sometimes performed by the manufacturer, but chiefly by persons termed wool-staplers, who purchase the raw material from the grower, and dispose of it, after it is assorted, to the manufacturer. The process of stapling is best carried on in districts where the manufactures themselves are established, both because of the superior skill and experience which the workmen there possess, and because of the staplers being thus able to supply the manufacturer with that precise kind of wool which the wants of a present market may require.

IV. THE GOAT.

Of the species of the genus *Capra* enumerated by naturalists, that which is supposed to give origin to the greater number of the domesticated races, is

Capra ægagrus—The Wild Goat.

The goat appears to form the connecting link between the sheep on the one hand, and the antelope tribes on the other. It is a lively creature, full of seeming caprice in its motions, and, although fitted for a life of liberty, yet easily domesticated, and becoming attached to its protectors. It is the natural inhabitant of a mountainous region; it delights to stand on the summits of rocks; it climbs the steepest ascents with ease, and in springing

from crag to crag, alights securely on the very verge of the precipice. Its feet, which are hollowed out, and have sharp edges, are nicely suited to this condition of life. It is not fond of feeding on the herbage of plains, but deserts them to browse on the heaths, shrubs, the wild thyme, and other plants of the mountains. It is not well adapted to a country of enclosures, because it browses upon the twigs of hedges, and escapes over the barriers intended to confine it.

It is in wild rocky countries, therefore, that the goat is chiefly reared; but often it is domesticated in the plains for the production of milk, for which the female goat is eminently adapted. She gives a great quantity of milk for so small a creature, and that rich, nourishing, and light. Like the cow, she yields it freely to the hand, and for a long time. She is readily taught to suckle the young of other animals, and becomes attached to her adopted offspring. She feeds readily in situations where the cow could not subsist, and that is a quality which gives a high value to the goat in many countries.

But in this island, the cultivation of the goat is limited and partial. It is chiefly confined to the mountainous parts of Wales, to parts of the remoter Highlands of Scotland, and to the little farms of the poorer peasants of Ireland, whose scanty possessions will not support a cow. In such a case as the last, the goat is a valuable creature, being easily and quickly reared to maturity, and feeding on herbs which other animals would reject.

The great objection to the rearing of the goat in this country is the want of demand for its flesh. Even the kid, whose flesh is known to be so delicate and nourishing, is in no estimation amongst us, and hence all the other properties of the goat are insufficient to render it an object of profitable production. But the goat, although it never can be so valuable here as in the dry and rocky countries of the south of Europe, does not deserve that entire neglect with which it is treated. It arrives early at maturity, and is very prolific, bearing two and sometimes three kids at a birth. It does not produce wool, but its hair may be shorn, and is of some little value; and its skin, and especially

that of the kid, is in demand. It browses on heaths, and on plants rejected by other animals; and thus might, in certain situations, be fed in addition to other flocks, without injuring the herbage. The flesh of the old goat is indeed tough and strong-tasted, but it may be salted, and dried like bacon, as in Wales; and with respect to the flesh of the kid, this is not surpassed by that of the finest lamb. The goat, therefore, might certainly form an addition to the comforts of the cottagers of this and other parts of Europe, by supplying them with cheap food and milk.

V. THE HOG.

1. Species and Varieties.

Of the Hog tribe, various species exist in the wild state. That which is believed to be the parent stock of the common domestic hog and its varieties, is,

Sus aper—The Wild Hog.

The wild hog is a bold and powerful animal, found in Europe, Asia, Africa, and the Islands of the Eastern Seas. He dwells for the most part in moist and shady situations, and he feeds chiefly on plants and roots. In a state of nature his senses are acute, his ears very moveable, and his touch and smell so delicate, as to lead him to his food below ground, which he grubs up with his strong and flexible trunk, and this faculty he retains when in a state of slavery.

The female carries her young about four months, and she is rarely seen with the males but in the rutting season. She suckles her young for several months, and retains them near her for a considerable time afterwards, to defend them. When assailed, she protects her offspring with amazing courage, and the young reward her cares by a long attachment. She is sometimes seen to be followed by several families, forming a troop, formidable to their assailants, and destructive, by their ravages, to the culti-

vated fields. A remarkable contrast with the long cares of the female is the solitary habit of the adult male, who will even, at their birth, destroy his own young—a singular instinct of nature, given to him as well as to some other animals.

Although the domestic hog loses many of the characters of the wild race, he retains enough of them to prove the affinity; and all question upon the subject of his origin is removed by the change produced upon the progeny of the wild hog by domestication.

One of the most remarkable circumstances in the history of the domestic hog is, his general distribution over so many countries and distant islands, where no trace of any wild animal of the species exists in record or tradition. He exists in vast numbers in China and the islands of the East. He was found extensively in the islands of the South Sea, when first visited by European voyagers, furnishing the principal animal food of the natives; though it is believed by many naturalists that, of the hogs found in the Asiatic and Polynesian islands, some are derived from a source distinct from the Sus aper. The common hog is not indigenous to America, but was carried thither by the Spaniards; and he was not found amongst the quadrupeds of New Holland, though he has now multiplied greatly there. This universal diffusion he seems to owe to his extraordinary fecundity, his adaptation to every climate, and the facility with which he may be transported from one place to another.

The hog, though chiefly herbivorous in his natural state, may be fed equally well on animal food. It is this which renders him the most easily and cheaply reared of all the domestic quadrupeds.

Like the horse, the ox, and the sheep, the hog is affected in his character, size, and form, by the physical state of the countries in which he is naturalized. But he is more the creature of artificial feeding than the sheep, the ox, or the horse; and hence his size and other characters are not so much dependent on the nature of the country in which he is reared. To the variations produced on him by external causes, we apply, as in the case of other

animals, the term *breeds*. But almost all the breeds of this country have been modified more or less by admixture with the races of other countries, as with those of Spain and other parts of the Mediterranean, with those of Africa, but above all with the Siamese race of the East.

The Siamese breed has the skin of a rich copper colour, but, like all the domesticated animals, the colour varies with different conditions of climate, food, and culture.

Of this widely extended race are the varieties commonly termed Chinese, of which great numbers have been introduced into England. They are frequently black or brown like the parent stock, but often white. They are for the most part less than the common swine of Europe, but they are distinguished by their peculiar aptitude to fatten. Their bones are small, their limbs short, their ears erect, their skin and bristles soft, and their general aspect is delicate.

The introduction of this race has insensibly produced a great change in the character of all the breeds of this country. It has been made to cross the greater number of them. It has diminished the size, but removed the former coarseness of form, and increased the aptitude to fatten. The pure breed is little cultivated, and it is through the medium, therefore, of its crosses with the native stock, that its value is chiefly known. In this respect, the introduction of the Eastern hog into England has been singularly beneficial.

The varieties which may be called native in the British Islands may be divided into two general classes. 1*st*, Those which are of small size, and have the ears erect or suberect; and, 2*d*, Those of larger size, which have the ears more or less pendent. Of the first class are those of the Highlands of Scotland and some other mountainous districts: of the second, the larger swine of the lower country.

The native breeds of the Highlands and Islands of Scotland are of small size, of a dun colour, with erect ears, rounded back, low shoulders, and with coarse bristles along the spine. They resemble the wild hog in their general form. They are usually

left to search for their own food; and they will graze on the hills like sheep, and find their way to the shore on the ebbing of the tide, to feed on sea-weeds. They are far inferior to the improved varieties of the lower country; but they fatten, when supplied with proper food, more readily than their rough exterior would indicate.

The Old English Breed may be held to be the type of the larger swine of England. It is distinguished by its great size, its lank form, and its pendent ears. Remnants of this unimproved race are yet to be found, but for the most part they have given place to the more improved varieties. Although of defective form and slow in fattening, the females are admirable nurses of their young: and when crossed by improved males, as the Berkshire, they produce a progeny possessing the aptitude to fatten of the male parent, with the large size of the dam.

The Berkshire was the earliest improved of the breeds of England, and is now the most generally diffused of all others. It has been formed by a mixture of the blood of the Eastern hog with the ancient swine of the country. The great improver of this breed was Mr Astley of Oldstonehall. The modern Berkshire, however, is of less size than the older breed; but still the animals are usually of the larger class of swine. Their common colour is a reddish-brown, with dark spots; but many of the modern breed are merely black, manifesting their approach to the Siamese character; and sometimes they are black, broken with white, indicating the effects of the cross of the White Chinese. The Berkshire is justly regarded as one of the superior breeds of England, combining good size, with aptitude to fatten; and their flesh is fitted for pork or bacon.

In Yorkshire, Lincolnshire, and other eastern counties, there are breeds of a large size, of a white colour, and with pendent ears. They have been all more or less affected in their size and characters by crossing. A variety termed the Suffolk, is so named from the county of Suffolk, which has long produced great quantities of pork, chiefly for the supply of London. The Suffolk hogs have been crossed again and again with the Chinese, or de-

scendants of Chinese crosses, so as to reduce the size for the purpose of suiting the taste of the consumers. The Essex breed has the same general characters as the Suffolk; but generally with thinner skins, and bristles approaching more to hair.

The same system of crossing has been applied to all the former breeds of England, as the Rudgewick, the Cheshire, the Shropshire, so that the characters applied to these varieties by former breeders can scarcely be now traced in the progeny.

Varieties have been frequently introduced from the countries of the Mediterranean, and been preserved for a longer or shorter time free from intermixture. One of these, the Maltese, was at one time in considerable favour. It is of small size, of a black colour, and nearly destitute of bristles. Another more recently introduced is the Neapolitan. The animals are of small size, of a round and delicate form: their skins are of a coal-black colour, and at the first introduction they are almost destitute of bristles; but when several times bred in England the bristles come. They have a great aptitude to fatten, and have on this account been received with favour; and they produce good crosses with the native stock.

In Scotland there are various mixed kinds. On the east coast the farmers prefer the small and kindly fattening hogs; on the west coast, where the dairy prevails, and the curing of bacon is established, they prefer the larger breeds. In Ireland vast quantities of swine are reared, which used to be of a large size and coarse form. But within the space of a few years, a prodigious improvement has taken place in this part of the live-stock of Ireland. This has been effected chiefly by the introduction of improved males of the best English breeds, as the Berkshire and the Suffolk.

2. Form.

The same external characters indicate, in the hog, a disposition to fatten, as in the other live-stock; and there is no other animal

which can be made by cultivation to present so great a combination of these characters, or which can be so easily improved in its form, from the facility with which it receives the characters of its parents, and from its rapid powers of increase. The chest should be deep and broad, the ribs largely arched, the neck short, and the head and limbs small; the bristles should be soft, approaching to hair, and the skin soft and elastic.

3. Rearing and Feeding.

The sow goes with young 112 days. She is fit to receive the male in the first year of her age, and the latter is able to propagate his species at the same early period, but he should be twelve months old before he is admitted to the female. The female produces from five to ten or more at a birth, and she can easily be made to produce and rear two litters in the year; and she may even rear five in two years. She is ready to receive the male soon after the birth of her young; but the time should be chosen which allows her to produce her litter at the most convenient season. Thus, if she is to be made to litter twice in one year, the first should, if possible, be produced about the beginning of February, and the second about the beginning of August, so that the last litter may gain full strength before the arrival of cold weather.

When the sow is with young, she should not be wholly confined to a pen, but be suffered to walk at large in a yard or other convenient place; care being taken that, as the time of producing her young draws on, she shall not be crowded with others, lest she be injured by their feet.

The time when she is about to produce her litter will be known by her carrying straw in her mouth to make her bed. Before this, however, she should have been separated from her fellows and carefully littered. The straw should be short, and not in too great quantity, lest the pigs, nestling beneath it unperceived by the dam, be crushed by her when she lies down.

While nursing, she should be well fed, and the pigs accustomed to feed from a trough on milk, whey, or any liquid food, mixed with a little meal or bran. In 30 days the males may be castrated, and a like operation, though not absolutely necessary, may be performed upon the females at the same time.

During the period of nursing, the dam and her young should be lodged dry and warm. They should be fed three times in the day with whey, milk, and a little water slightly warm, mixed with bran, meal, or any farinaceous substance, and when the pigs are in the course of feeding from the troughs, the mother may be allowed to go at large for an hour or two.

In six weeks, if they are well fed, the pigs may be weaned, but should they not have been well fed, eight weeks will be required. When weaned, they are to be fed three times a-day with wheat-bran, barley-dust, or any farinaceous food, mixed with water warmed to the temperature of the mother's milk, and with whey, or other refuse of the dairy or the kitchen. In a few weeks they will begin to eat potatoes, turnips, and all other food.

The young pigs are sometimes disposed of when sucking the dam. In other cases they are sold when weaned to persons who design to fatten them; and in other cases they are fattened by the breeder himself.

When they are fattened by the breeder, two modes of feeding may be adopted. They may either be suffered to go at large, or they may be kept in pens and houses. By the first of these methods, after being weaned and fed for a period till they are able to shift for themselves, they are turned abroad to pick up what they can in the straw-yards, a little green food, as tares or clover during summer, and turnips or potatoes during winter, being supplied to them. They do not, under this management, receive any more expensive feeding until they are put up finally to be fattened, when they are confined for a few weeks, and fed on farinaceous and other food. The pigs intended for this species of management should be the best of the smaller varieties; and they may be killed for domestic use, or disposed of when of 7 or 8 stones weight. All the accommodation required under

this system of management, is a few pens with sheds; first, for the breeding sows when nursing their young; and secondly, for the pigs which are in the course of being fattened.

In all cases upon a farm, a certain number of pigs may be kept at large in this manner for picking up the waste of the farm-yards. But the regular course of management, and that to be adopted where the feeding of the animals is carried on on the larger scale, is to have separate feeding-houses for the pigs, in which a greater or lesser number can be kept.

The same general principle of feeding applies to the hog as to the other domestic animals. The breeding stock is to be kept in good order, but not over-fed; the fattening stock is to receive a full allowance of good food from the period of weaning until it is fat.

The food of the pigs is every kind of animal refuse, as that of the dairy and kitchen. Roots of any kind, raw and boiled, will be eaten by them; but it is better that this species of food be boiled or steamed. Bran, steamed or boiled, is likewise a nourishing food for pigs; beans and pease bruised may be also given to them; and brewers' grain and wash furnish one of the best kinds of food that can be supplied. Hay or dried fodder is not relished by this class of animals; they require food of a moist and succulent kind, and, therefore, though they dislike dried forage, they will not refuse hay, and even straw, if chopped and boiled. They feed on green food of all kinds; and hence clover, lucerne, and tares, may be employed in feeding them in summer, though to fatten them finally, some farinaceous or other nourishing food will be required. They will also graze like sheep or oxen; but grass consumed in this manner is not the natural food of the animal, which consists of roots rather than of herbage. The feeding of pigs on herbage, is merely to carry them on for a time till more fattening food can be procured for them. When fed on herbage, a ring must be passed through the cartilage of the nose, to prevent their following their natural instinct of ploughing up the ground; but the same purpose may be more effectually served, by dividing the tendons by which they are enabled to move the

snout. Acorns and beech-mast are a favourite food of the hog, but these are rarely furnished in sufficient quantity for the purpose of feeding; though in cases where there is access to woods producing these fruits, hogs may be turned into forests with advantage. All kinds of spoiled or waste fruits may be given to them; and in the cider districts, accordingly, the refuse of the cider-press is employed for feeding them. In short, the animal is omnivorous, and there is not any species of animal or vegetable food which may not be given; and in the case of no other of the larger animals, accordingly, is the process of feeding so simple.

Pigs ought to be fed three times in the day, and the troughs in which the food is placed should be emptied before a fresh supply is given, and kept perfectly clean. It is well to vary their food, to mix it with water or other liquid, and not to overload them too much at a time. It is a great error to leave these animals in a state of filth and neglect. The hog is not a filthy animal by choice; he delights in a clean bed; he will wallow indeed in the mire, like the elephant, the rhinoceros, and other pachydermatous or thick-skinned animals to which he belongs; but this is not because he prefers filth, but because he loves coolness and moisture.

There are two purposes for which pigs may be fattened. The one is to yield pork, which may be used either fresh, salted, or pickled; and the other is to produce bacon, which is prepared by salting and drying the flesh. When fed for pork, which is the most convenient system in the practice of the farm, the pigs may be reared to the age of six or eight months; when intended for bacon, they must be reared to a greater age and size, as ten or twelve months. When the object is pork, the smaller class of early-fattening pigs is to be preferred; when bacon is desired, the larger class should be cultivated.

In the case of feeding for pork alone, it has been computed that, upon a regular farm, with a supply of tares and clovers to the animals in summer, and of potatoes and turnips in winter, and with no other feeding than the refuse of the barn, milkhouse, and

kitchen, one pig may be fattened in the year for every six acres of land under corn-crop. Thus, supposing there are to be 240 acres in corn-crop, the quantity of pigs fed annually upon the farm might be forty. To fatten this stock, in addition to what they can pick up in the straw-yards, about an acre and a quarter of clover, and an equal quantity of potates during winter, will be sufficient. To keep up the number, three breeding-sows will be required, of which two should be sold in each year, their place being supplied by an equal number of younger ones reared upon the farm. The surplus beyond the quantity of forty, which it is proposed to feed, may be disposed of when weaned. This is a method of management practicable upon ordinary farms, without any interference whatever with the food and attention required for the large stock.*

Another method of management may be adopted. This is to take only one litter of pigs from each sow, to sell the pigs as soon as they are weaned, and immediately afterwards to fatten the sows. This will be a very profitable species of management, provided there is a sufficient demand in the district for so many pigs when weaned.

Pigs, it has been said, may either be used for pork, fresh, salted, or pickled, when they will be ready in six or eight months, or for bacon, when they will be ready in ten or twelve months.

In the case of pickling pork, the carcase is to be cut in pieces, and may be packed in kits containing from 1 to 2 cwt. Salt is then dissolved in water, so as to form a strong brine, and this being boiled, is cooled again and poured upon the pork so as to cover it. This simple process prepares the pork for market; so that the preparation of it may be carried on with the greatest facility upon the premises of the farmer.

When the animals are designed for bacon, the operation is performed by cutting the body so as to separate the hams or legs from the flitches or sides, the body for this purpose being cut first along the back-bone and then transversely. The hams and flitches are then laid on boards, sprinkled with saltpetre, and

* Brown on Rural Affairs.

covered with salt. They are then separately salted again, and at length put in a chimney or smoke-house to dry. The proper period for curing bacon is in the cold months, namely, from the middle of September to the middle of April.

Private families in the country may supply themselves with fresh or pickled pork by very easy means :—Let a good sow be procured of the early-fattening kinds, as the Berkshire or Chinese cross. This sow will produce from fifteen to twenty pigs every year, and these pigs may be rendered sufficiently fat for domestic use when four or five months old. It is unnecessary to keep a male, if one amongst the neighbouring farmers of the same breed is to be found. Let a small house be formed sufficient to hold two pigs at once, and for convenience as near the kitchen as possible. Let a pig be killed every three weeks, the oldest being taken first, and his place being supplied by another. With attention the animal will be ready in six weeks after being put up. In this manner a family may be supplied with fresh and pickled pork plentifully throughout the whole year, and at a very small expense. During the hot months the pork may be pickled in a cold cellar in a manner sufficient for household use ; or a portion, if wished, may be converted into small hams like those of Westphalia.*

When we regard the number of mankind fed upon the flesh of this animal, it must be seen that he occupies an important place in the domestic economy of countries. His flesh is perfectly nutritive, and, from its ready reception of salt, it is better fitted for preservation than that of any other animal. It is thus eminently adapted for sea-voyages, for which purpose it is largely used. It forms a great part of the animal food of the labouring classes of Europe. The hog is truly the poor man's stock, since it may be raised by the cottager as well as by the breeder on the larger scale. There is no animal which, in proportion to the food consumed, yields so great a quantity of muscle and fat. His flesh, indeed,

* Henderson on Swine.

may not be so profitable as that of the sheep and ox; but this arises from the facility of production, and the consequent tendency of the market to be overstocked.

To the settler in a new country, the hog is the most valuable of all the larger domestic animals used as food. He is beyond every other quickly multiplied, reared, and brought to the required maturity. The clearers of land in the American forests could hardly subsist during their first year of labour and danger without this creature.

And in our own country it is a great error for a farmer, however extended his own concerns may be, to disregard this branch of farm-stock; it is to him a source of household economy and comfort. He can raise the most delicate pork for use at all times, and with the greatest facility; and will always derive a sufficient profit by the sale of the remainder, to repay him for his feeding, and induce him to give attention to this branch of economy.

VI. THE RABBIT.

Of the genus *Lepus*, the species to which the term Rabbit is usually applied are:—

1. Lepus cuniculus—The Common Rabbit.
2. Lepus tolai—The Siberian Rabbit.
3. Lepus americanus—The American Rabbit.

That which forms the subject of cultivation in the north of Europe is the Common Rabbit.

The rabbit is a subject of considerable attention in some countries. It is reared partly for its fur, which is employed chiefly in the manufacture of hats, and partly for its flesh. It is a wonderfully prolific creature; it will breed seven times in the year, and produce from five to ten young at a time. Were its numbers not thinned by a multitude of beasts of prey, as the fox, the weasel, the polecat, and the hawk, it would soon overspread the face of the country; but these animals to which it serves for

food, retain it within its due limits; and as if for a further security against its excessive multiplication, the male parent is endowed with the propensity to destroy his own offspring.

At the age of six months, the rabbit is able to propagate. The female goes with young thirty or thirty-one days. Previous to bringing forth her young, she makes a bed of down, which she pulls from her own fur. She tends and suckles her young with surprising solicitude, and never leaves them except for necessary food. She conceals them from the male, lest, obeying his natural instinct, he should destroy them.

The flesh of the rabbit is, in some countries, much esteemed. In England it is little valued, although still the consumption in the great towns is considerable.

The rabbits with us are of two kinds: the wild rabbit, which s reared in warrens, in a state of comparative liberty; and the tame rabbit, which is reared and fed in yards and houses.

The fitting soil for the warren is sand, and the best situation for it sandy downs, which are of little value for tillage. Warrens are of every variety and extent. When not naturally stocked, they may be stocked at the rate of three couples to the acre, there being one male for every seven or more females. The warren should be enclosed by a wall, so as to prevent the depredations of the rabbits on the neighbouring fields. The management of the warren itself is simple. It is to be protected from dogs and beasts of prey, while mice, rats, and other vermin are to be destroyed. The rabbits are themselves caught in traps and nets, and sent to market in such quantities as they are produced. They are generally disposed of by the dozen or hundred, and their fur is of the most value from October to January.

It is generally found that the rabbit-warren in this country is a very unproductive species of property. At the present price of the animals, there is scarcely any inducement to preserve existing warrens, and none to form new ones.

If the rabbit, then, is to be cultivated in this country for profit, he must be reared in the house or yard, and the variety to be selected is the tame or domestic rabbit.

The domestic rabbit is larger than the wild, and is greatly diversified in size and colour. His flesh is more white and delicate than that of the wild rabbit, but generally less valued, because possessing less of the game flavour.

The variety chosen for breeding should be of the larger kinds. Those termed the French and Turkish rabbits are much esteemed. The rabbit selected for breeding, we are informed by the breeders of them, should be wide in the loin and short-legged. It thus appears that the external characters which indicate a disposition to fatten in the other domestic animals, indicate the same property in the rabbit.

In the management of the rabbit, the utmost attention must be paid to ventilation, cleanliness, and food. The animals are most conveniently kept in boxes, or compartments termed hutches, one above the other round the room. Each hutch intended for the does should have two divisions, one for feeding and the other for sleeping. Those are single which are intended for the use of the weaned rabbits, or for the bucks, which are always removed from the female after copulation.

There should be little troughs in the hutches for the food, which consists of corn, hay, roots, and green plants, or any farinaceous substance. Boiled potatoes are an excellent food for the rabbit, as for every kind of herbivorous animal.

The female, when the time of parturition approaches, makes her nest, for which hay is to be furnished her. She bites it with her teeth into the requisite size. She generally produces from five to ten young. At the end of six weeks the male is again admitted to her, and the young ones are weaned, or else she is allowed to suckle them for two weeks more.

They are either sold from the teat, when they are extremely delicate, or they are kept on for a certain period and fattened. Good and nourishing food is to be supplied to them, and three months' feeding is generally considered necessary to fatten them properly.

From the statement given, it will appear that the rearing and feeding of the domestic rabbit is extremely easy, and that there

is no class of animals so prolific. The cultivation of the animal, however, can only be carried on successfully where there is a demand for the produce. But if it were the habit of the people, the rearing of the domestic rabbit by various classes in this country would furnish, at little expense, a grateful change of wholesome and nourishing food.

VII. DOMESTIC FOWLS.

The domestic fowls reared in Europe for food are comprehended under two divisions :

1. *Gallinaceæ*, the Cock kind, comprehending the Common Cock, the Turkey, the Guinea-fowl, the Peacock, and the Pigeon.
2. *Palmipedes*, the Web-footed kinds, comprehending the Duck, the Goose, and the Swan.

1. The first in importance of the gallinaceous fowls, is *Phasianus gallus*, the Domestic Cock. To what region we owe this creature is unknown. He is found from the equator to the limits of the temperate regions. In Asia and its islands he is very abundant, and sometimes of large size and great beauty. The large Cock of the forests of the East, termed the Jungle-Cock, is one of the species or varieties in its wild state, and is supposed by some naturalists to be the origin of the domestic kinds.

The male of the domestic species, were we not daily familiarized to the sight of him, would appear to be a very graceful bird. His gait is erect, his eyes are sparkling, he is armed with spurs for his defence, and he is endowed with a courage which often causes him to die rather than yield to an enemy.

The female is remarkable beyond all other birds for her fecundity ; she continues to lay eggs throughout a great part of the year ; the period in which she ceases to do so, or does so very sparingly, is that of moulting, which generally lasts from one to

three months. After having laid a certain number of eggs, the desire of incubation takes place. This is indicated by strong emotions, and a peculiar cry; and she will then sit on any eggs that may be presented to her. Many expedients, some of them very cruel, are practised to check the instinctive passion, so as to cause the animal to lay eggs rather than to hatch.

It is remarkable that while some of the females shew this desire in the strongest manner, others scarcely manifest it, or, shewing it, it quickly leaves them. Hence, while some are engaged in producing eggs, others are ready to serve the office of mother, and on this account there is no kind of the domestic fowls that can be propagated so quickly, and in such numbers.

The period of hatching is twenty-one days. The female during this time manifests increasing watchfulness. She will scarcely be induced to forsake her charge, even by the most pressing claims for food, and hence food should be placed within her reach. The number of eggs which one mother is allowed to hatch, is generally from ten to fifteen.

The young is gradually nourished within the shell. It lies without motion; its position is remarkable; its breast is towards one end of the egg, which is formed large for that purpose; its legs are bent forward to the breast; its head is couched beneath one of its wings; and its beak rises from between the wing and the back.

When the time of its maturity is at length arrived, the desire of life and motion awakes. The little creature employs its beak, thus singularly placed, for the purpose of breaking its covering. It is heard to tap the shell; the emotions of the mother increase as she listens to the attempt of the young to come forth. The beating of the beak is generally continued for two hours, sometimes for six hours, and sometimes for a longer time. At length the shell is broken, and the young is enabled to come forth from its marvellous mansion.

The anxious mother has no milk to give to her young when they come into day; but nature has provided for all their wants.

The mother teaches them to find their food almost as soon as born, and their little bills are sufficiently hardened at their birth to pick it from the ground.

The change of nature in the parent is very remarkable. From the most timid of creatures, she now becomes fierce and courageous; she will attack the largest animal in defence of her young; she watches them with surprising solicitude; she shelters them under her wings, and leads them where food is to be found. After a time her cares cease; she gradually recovers her natural timidity; she finally resumes all her habits, and leaves her long-cherished offspring as if never to know them more.

The varieties of the common fowl in this country are very numerous, and are distinguished from one another by their size, colour, and fecundity.

The Game-fowl is a very singular creature on account of its habits. Its size is less than that of the common kind; but the symmetry of its limbs is greater, and the beauty of its plumage is remarkable when not mutilated for the barbarous sport for which it is destined. Its flesh is white, and esteemed beyond that of all the common kinds for its delicacy and flavour; but the singular pugnacity of its disposition, which shews itself at the earliest period of life, deters all breeders from rearing it except for the purpose of gaming. Whole broods, scarce feathered, become blind from continued fighting; and a very small number, accordingly, of any brood can be reared. Neither can they be employed to cross the common fowls, because they never fail to convey the same pugnacity of disposition to the offspring.

This singular temperament of the animal has been known, and turned to a barbarous purpose, from the earliest times; but whatever may be the design of this peculiar nature of the animal, it cannot be imagined that it was intended to minister to the cupidity and evil passions of gamblers in a cock-pit. The cruel sport, therefore, to which the nature of the animal gives rise, should be proscribed by public feeling.

The Dorking fowls, so named from a town in Surrey, in the neighbourhood of which they are raised, are the largest and finest

of our domestic breeds. Their colour is wholly white: their body is capacious, and they are prolific layers of eggs.

Equal to the Dorking in estimation are the Poland fowls. Their colour is black, and their heads are flat, and surmounted with a crown of feathers. They are a very useful variety, prolific of eggs, but less inclined to sit than those of any other breed.

The Bantam is a little Indian breed, very delicate to eat, but, from the smallness of its size, not of any economical importance.

The Chitagong or Malay fowl, is the largest breed that has been yet brought to this country; but the flesh is regarded as inferior to that of the Dorking and Poland varieties.

When it is wished to form a breed of fowls, the breeding should be from a young stock. Hens are at their prime at three years old, and decline after the age of five. The best period to commence breeding is in spring.

The methods of feeding fowls are various. The most common is to suffer them to range about the homestead, in which case they are termed barn-door fowls.

Whether the fowls are suffered to go at large, or are confined, there should be a poultry-yard, where they may be regularly fed, and this should be on dry ground, and well gravelled. There should be water in the yard, and it should be sheltered from the north and east. There may be put in the yard a quantity of dried sand, that the animals may indulge the propensity natural to them of rolling or basking.

There must likewise be a house for the animals to roost and hatch. In this should be placed perches, to which they may ascend by steps without flying, and these perches should be placed on a range or level, and not one above the other; and round the interior should be placed boxes for the fowls that are hatching. When there is only one house, the boxes for the web-footed fowls should be below, and those for the hens above, protected by little boards in front, and with steps by which the fowls may ascend.

The common fowls of a farm may usually be suffered to go at large; care, however, being taken that they shall be regularly fed

in the poultry-yard morning and evening. But when fowls are reared in large numbers for sale, feeding-houses must be employed, in which are troughs with water and food placed all around, so that the animals may feed constantly without interruption. Poulterers know how to fatten fowls with great expedition; and their method seems to be to give every kind of nourishing food. It is indeed, under every circumstance, the rule of experienced feeders, to give the animals a full allowance of food from their birth to their maturity. The same rule applies to them, in this respect, as to other animals reared for food.

Wheat, barley, and oats, are all employed for the feeding of poultry. Poultry, indeed, will feed on any kind of farinaceous substance, and the better the quality of the food, the more will the animals profit by it. And not only will they feed on farinaceous food, but on animal substances, as grease, suet, and milk; sugar and treacle, too, are consumed by them; and it is by this kind of mixtures that poultry-feeders are enabled to produce so rapid a degree of fatness.

The cramming of poultry consists not only in feeding with these substances, but in forcing them down the throats of the animals. The ingredients employed are made into little balls, and the fowls are kept in coops, and crammed night and morning. In this way they are fattened in a very short time.

Eggs are an extensive product of common poultry. They form an object of vast consumption, and are produced in numbers not to be computed. To preserve eggs, the pores of the shell should be rendered impervious to the air. Unctuous substances of different kinds are employed for this purpose, as suet melted, oil, and the like. Other substances are employed, as water saturated with lime and salt.

2. The Turkey, *Meleagris gallo-pavo*, is a native of America. He was found by the Spaniards, both in a wild and domesticated state; he was named the Indian Cock, and sometimes the Peacock of the Indies; he seems to have been introduced into this island soon after the discovery of America.

In his wild state, the colour of the turkey is black, variegated

with bronze and glossy green; and his quills towards the ends are tipped with white. By domestication he acquires that variety of colours which we see him to possess. In his native woods, the turkey is found in large flocks; he roosts upon the highest trees, and becomes an easy prey to the hunter; he retires before the progress of the settler, taking refuge in the boundless forests of the interior.

The turkey is an important addition to the domestic fowls of Europe. There is but one species of the domesticated turkey, but numerous varieties, distinguished chiefly by their size and colour.

The turkey is more tender, and difficult to rear, than the common domestic fowls. The hen lays a considerable number of eggs in spring; the period of her incubation is thirty days; and from ten to fifteen eggs are usually assigned to one female. She will sit upon her eggs frequently without the desire to leave them, and hence the propriety of supplying her with water and food while sitting. Her cry at the period of maternal solicitude is plaintive and expressive, but she treats her young with less seeming care than might have been looked for. She travels with them very fast to great distances, and often leaves them straggling behind her; hence it is usual to confine her to a coop till the young have acquired strength to follow her. And frequently even, on account of her wandering habits, her eggs are given to be hatched by a common hen. She is wonderfully vigilant when birds of prey appear; and, by a peculiar cry, gives the alarm to her brood, which instantly seek for shelter, or couch themselves upon the ground.

As soon as the young are hatched, they must be withdrawn from the nest, and kept warm. The hen and brood must then be housed for some time, after which she must be cooped during the day in the open air, till the young acquire strength to follow her. During this period the young are fed on farinaceous food, kneaded with water, and mixed with cresses, nettles, or other green herbs, cut small. Though they are tender at first, yet when half-grown, and well feathered, they become hardy, and will range abroad,

providing themselves with insects and other food; but care must be taken that they be well fed when let out in the morning, and when they return in the evening. It is to be observed, that, if a large wood be near, the creatures, with the instinct of their race, will stray towards it, without any seeming wish to return.

When they are put up for final fattening, sodden barley, or the meal of oats, barley, and wheat, is their appropriate food. A common practice is, after they have been allowed to glean in the stubble fields in autumn, to put them up for fattening. A good weight for a turkey is 15 lb.; but they are sometimes fed to 20 and even 30 lb. The process of cramming is also adopted with the turkey, and thus it is compelled to become fat in the shortest time. The eggs of the turkey are regarded as delicate by those who are used to them, but they are not much an article of consumption.

3. The Pintado or Guinea-fowl, *Numidia Meleagris*, is a native of Africa, where it is found in vast flocks; but it is now diffused over every part of Europe, the West India Islands, and a great part of America. The pintado is a restless, noisy bird; the female lays numerous eggs, which are smaller than those of the common hen, but esteemed much more delicate; like other gallinaceous birds, she is apt to secrete her eggs until she has produced her brood.

The pintado is an agreeable variety in the poultry yards of Europe, liked by some for its flesh, and by all for the delicacy of its eggs; but it is of little economical importance. The chicks are very tender, and should not be produced too early in spring. They are generally hatched by the common hen, who either covers a larger number of them, or is found to be a more careful nurse than the pintado herself.

4. The Peacock, *Pavo cristatus*, need scarcely be mentioned as a bird of economical use. Pea-hens and pea-chicks, indeed, are occasionally used for food, but this splendid creature is, and ought to be, regarded solely for his beauty. The advantages to be derived from rearing it for food are not to be thought of.

5. The Common Pigeon, *Columba livia*, is of a race of birds

multiplied throughout the warmer and temperate regions; but it is in the warmer regions that they attain their greatest size and beauty of plumage. They have been in all ages the favourites of mankind, to which their innocence and beauty seem to give them a peculiar claim. But if it be as farmers that we are to regard the pigeon, the beautiful favourite unfortunately cannot attract much of our regard. Nothing beyond the gratification of luxury can be derived from the cultivation of the domestic pigeon for food. In vain has it been asserted, that pigeons do not feed upon green corn, cannot dig into the earth with their bills, do little harm to the cultivated crops, and consume only the seeds of injurious plants. The experience of farmers shews that the damage done by these creatures to our various crops of wheat, pease, and beans, is very great; and certainly the waste is in no degree compensated for by the quantity which the animals afford of human food.

Yet, as pigeons are in demand as objects of consumption, and as they afford a luxury and convenience to those who live in the country, the subject of their management is, like every branch of husbandry, deserving of attention. If pigeon-houses are to exist at all, those who possess them should know how they are to be best managed, so that the largest return may be derived from them. Though there is scarcely any branch of the management of the domestic fowls more misunderstood, yet the essential rule of management is simple. Its principle consists in regular feeding, in giving sufficient space to the birds, and in paying a strict attention to cleanliness.

2. The next in order of the domestic fowls are the Web-footed. These birds, when domesticated, become enlarged in their form, and wholly the creatures of their new condition, though they still remain partial to an aquatic situation, swimming with facility, and feeding on fish, insects, and the leaves and grains of aquatic plants. They are hardy, easily propagated and fed, and afford a rich and savoury food.

1. The Wild Duck or Mallard, *Anas boschas*, is the original

of the common domestic species. It is widely diffused over the world, inhabiting Europe, Asia, and America. These birds live in the marshes, lakes, and rivers of the North in incredible multitudes. In autumn, they migrate southwards in numerous bodies, the greater part returning in spring to their former haunts, though flocks and scattered pairs remain and breed in the morasses and rivers of lower latitudes.

The wild duck in its natural state is a wonderfully shy and cautious creature. It breeds once in the year, the pairing time commencing about the end of February, and each couple living apart amongst the reeds of lakes, rivers, and marshes, where they breed. Nothing can be more tender than the care of their offspring by these birds. The nest is formed on the ground, generally in a tuft of reeds or rushes, bent into form, and lined with the down of the parents. The incubation lasts thirty days; when the female quits her charge for food, she covers up the eggs, the male in the mean time keeping watch near the nest; and when she returns, she approaches cautiously, winding that she may avoid discovery. The young burst their shells nearly at one time, and in a few hours the parents conduct them to the stream, where they at once begin to swim, and feed on herbs and insects; and at night they are gathered together under the wings of the dam. In three months they can fly; and in three months more their growth and plumage are complete.

The domestic duck adapts his habits to his new condition. He no longer retires with one female to pair, and tend his brood, but becomes polygamous; and he loses the caution and sense of danger which distinguish him in his wild state. Still as in the wild state, by means of his nicely-formed bill, he finds in marshes and elsewhere the food that is suited to him. He feeds alike upon animal and vegetable substances; on the spawn of fish, and the larvæ of insects; upon grass, the seeds of aquatic plants, and even sea-weeds. These birds may be said to be omnivorous, and this it is which, with their hardy qualities, renders them so easy of culture.

The duck begins to lay her eggs in February, and, obeying

her natural instinct, she will, unless confined, lay them abroad and conceal them. During the period of hatching, she requires no other care but to be kept undisturbed. When she wants food, she will go in search of it, covering up her eggs as in the wild state. When the young are hatched, they should be allowed to remain in the nest so long as the dam chooses; after which she may be put into a coop in the open air during the day for a short time. She should then have a full allowance of good food and water, while the young should likewise have a flat dish put down to them with water frequently renewed, with a proper supply of meal or other farinaceous food.

A common hen is frequently substituted for the natural parent to hatch the eggs of the duck. But wherever there are any pools of water, the proper nurse is the duck herself: she conducts her young to their natural element, and brings them from it when it is time; while, when a hen is the nurse, they disregard her signals on the bank, and do not themselves know when to return.

The feeding of these fowls is easy. In certain situations, they are allowed access to their natural haunts, the marshes and bogs, where they feed; and when they are to be ultimately fattened, they are fed for a short time on farinaceous food.

As in the case of other fowls, there are also breeds of the common duck more or less valued; and there are some singular varieties, as the hook-billed duck, reared in aviaries and poultry-yards.

The Mallard is the original of the ducks usually reared for economical purposes. Other species, too, are sometimes domesticated. One of these is the Chinese duck, *Anas galericulata*. A large species is the Muscovy duck, or, as he ought rather to be called, the Musk duck, *Anas moschata*, a native of Paraguay, and the neighbouring provinces. He there perches on trees by the sides of rivers and marshes, and breeds several times in the year; he is very shy in his wild state, but readily submits to domestication; he is larger than the common species, very prolific, and easily fattened.

2. The Wild Goose, *Anas anser*, is another of this valuable family, widely extended over the world, and susceptible of entire subjection to the will of man.

Like the wild duck, this fine animal quits the swamps of the vast wilderness of the North on the approach of winter, and migrates far to the South. From fifty to one hundred individuals are often in flight together, at a vast height, sometimes beyond the reach of vision, and only recognised by their shrill voices. All have witnessed the surprising regularity of their flight; the leaders forming the apex of an angle, and cleaving the air, as it were, for those that follow. They pursue their lofty flights from vast distances, and when they alight for food or rest, they station sentinels, to guard them from surprise.

Part of them remain to breed in the lakes, rivers, and fens of lower latitudes, but the greater number of them return to the boundless regions of marsh and forest, whence they had taken their flight, and where they can rear their young in security.

The domestic race of this species generally loses the desire of escaping, although a few instances occur of the tame joining the wild race. The tame variety is reared in every civilized country. Its habits render it an easily cultivated animal, and it is an object of great economical importance in the districts of fens and marshes, which are the most suited to the rearing of it.

The period of incubation is from twenty-seven to thirty days, and the female covers conveniently from eleven to fifteen eggs. She manifests the period by carrying straw in her mouth, and then a nest should be prepared for her in a secure situation. During the time of hatching, the male stands a watchful sentinel, and will fiercely attack the largest animals that approach the nest.

After the young are brought from the nest, the dam may be penned with them on a spot of dry grass, while farinaceous food, water, and any wholesome green herbs, must be supplied. After a short time, the dam and her brood should be allowed to forage for themselves in the fields and marshes. They are perfectly herbivorous, and will graze like sheep. Persons who are favour-

ably situated with respect to the means of rearing these fowls, seldom give them any more attention, than to drive the broods, with the dams, to the contiguous fens or marshes where they feed.

In situations less favourable, more attention must be paid to the feeding of them. They must be well supplied with food like other fowls, but it constitutes the particular facility of rearing these animals, that not only farinaceous substances, but every kind of edible herbs, as turnips, potatoes, and the refuse of the garden, may be given to them. They may be soiled, too, on clover and tares; and when being fattened, steamed potatoes, meal mixed with milk, and similar substances, may be given to them.

The young are either disposed of at a month or six weeks old, when they are termed green-geese, or they are retained till after harvest, and fed upon the stubbles, when they are termed stubble-geese. If they shall not have been sufficiently fattened on the stubbles, they must be put up to feed,—all that is necessary in this case being, to give them plenty of water, and constant food, and to litter them carefully with straw.

Besides the produce in flesh, there are derived from this animal down and feathers, both those of the wings, which are made into writing-quills, and those of the body, which are applied to different uses. This has given rise to the dreadful barbarity of plucking the animals, which is sometimes done five times in a year.

The only really important species reared in this country is that which has been described; but peculiar varieties or breeds are distinguished and valued according to their size and qualities. Of these the most esteemed are the Spanish and the Embden geese. These varieties are both white in their colour, and of good size.

Other species of the goose have been introduced into our pleasure-grounds or poultry-yards, as curious or ornamental. The Egyptian goose, or barnacle, *Anas ægyptiaca*, is remarkable for the veneration paid to it by the ancient Egyptians. The Chinese goose is a pretty animal, more graceful, and somewhat smaller than the common kinds. The Canadian goose, *Anas canadensis*,

too, has been domesticated in different parts of Europe, and become as familiar as the common kind.

3. The Domestic Swan, *Anas olor*, has in this country ceased to be regarded as food, and is now preserved solely for the beauty and majesty of his form, with respect to which he is the noblest of all the water-fowls. He feeds like the goose, but is more aquatic in his habits. He is gentle and familiar to his keepers, eating his food from the hand; but while engaged in the rearing of his brood, he is fierce and dangerous to be approached. He is a bird of great courage, but is never the assailant of others.

XI. GENERAL ECONOMY OF THE FARM.

1. Buildings of the Farm.

The buildings of the farm are to enable the farmer to thrash and prepare the produce of the ground for use; to preserve his corn and other seeds; to prepare and collect manures; to keep his working-cattle; and to divide, shelter, and feed his other live-stock.

For the economy of labour, the buildings of the farm should be as near as possible to the centre of the cultivated grounds; for most of the produce of the farm being, in the first place, conveyed to the farm-buildings, and the manure carried from them to the fields, it is important that the parts of the farm should not be so distant from the buildings that time shall be wasted by the men and working-cattle in travelling.

But, although a central situation of the farm-buildings is as much as possible to be aimed at, it is often necessary or expedient to sacrifice this convenience in order to secure others.

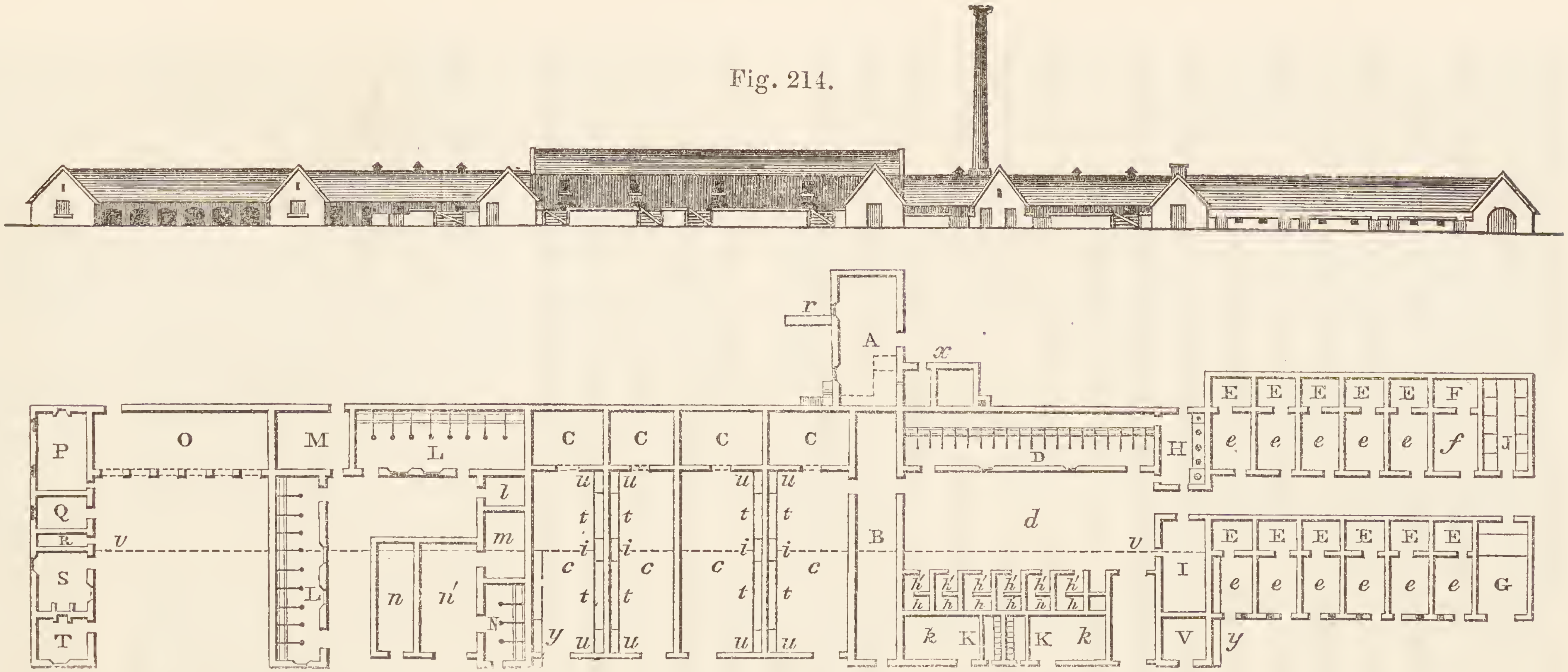
A primary object is, the obtaining a sufficient command of water for domestic purposes and the use of the live-stock. This cannot be obtained in every situation; and convenience of position, therefore, in the buildings, must often be sacrificed, in order to obtain the necessary supplies of water. Sometimes water can be procured in sufficient quantity by sinking wells; but it is always better that it be obtained by a constant flow or current, so that the stock of the farm may be supplied at all times without the labour of pumping. Where a brook or rivulet of any kind does not exist, water can be frequently conveyed to the buildings from a distance in drains or pipes: and when farm-buildings are to be erected, a preliminary examination of the means of procuring this necessary material must never be omitted. Besides the supply of water for domestic purposes and the use of the live-stock, it is often important to have it in sufficient quantity for a water-power. However beneficial, then, it be to place the farm-buildings in a centrical situation, this object must be sacrificed in order to secure other advantages.

The extent and arrangement of the different parts of the farm-buildings depend on the nature and size of the farm, and on the species of management to be pursued upon it. The principal parts of the farm-buildings, are the barns, the stables, the cow-houses and other feeding-houses, the shelter-sheds, the granary, and the cart-shed.

Figure 214, which is the ground-plan and elevation of a set of farm-buildings, is designed to illustrate the general principles of the arrangement of this class of buildings, without shewing those deviations which circumstances may require, or those details of practice which demand the attention of the architect. The size and arrangement of the buildings here shewn are intended for a farm of the larger class, and have a direct reference to the species of agriculture which has been explained in this work.

The most convenient disposition of the out-houses of a farm, suited to a mixed system of tillage and the feeding of live-stock as practised in this country, is in the form of a long rectangle,

Fig. 214.



A, Thrashing-barn, the dotted lines shewing the position of the thrashing-machine.
r, Gangway.
x, Engine-house.
B, Straw-barn.
C, C, C, C, Shelter-sheds.
c, c, c, c, Yards to do.
t, t, t, t, &c. Troughs for green food.
u, u, u, u, &c. Racks for hay.
D, Cow-house.
d, Yard.
E, E, E, E, E, &c. Sheds } for feeding.
e, e, e, e, e, &c. Yards } for feeding.
F, f, Shed and Yard for Bull.
J, House and pens for calves.
H, Boiling or steaming house.
I, Root-house.
G, Turnip-shed.
M, Hay-house.
L, L, Farm-horse stables.
N, Saddle-horse stable.
l, House for mare and foal.
m, Shed for colts.
n′, Yard.
n, Stable dung-heap.
O, Cart-shed.
h, h, h, h, &c. Sheds } for pigs.
h′, h′, h′, h′, &c. Yards } for pigs.
K, K, Houses } for poultry.
k, k, Yards } for poultry.
Q, Tool-house.
P, Carpenter's shop.
S, Smithy.
R, Coal-house.
T, V, spare rooms, one of which may be a House for bailiff.
i, i, i, i, Troughs for water.
v, v, Line of sewer.
y, y, Tanks.

open at one side, generally to the south, so as to admit the air to the cattle in the yards, and allow sufficient sunshine to them in winter. This is a point of practice which demands the more attention, as scarcely any error in the erecting of this class of buildings is more common with architects than to crowd the different parts of the buildings together, under the idea of giving to them greater compactness, as if a few square yards more, taken up in necessary buildings, were of importance upon a farm.

The Barns being the part whence the straw for fodder and litter is carried to the stables, feeding-houses, and sheds, they should be placed so as to afford the readiest access to these different buildings. It is common to place them as near the centre of the range as the general arrangement of the other buildings will allow. In the design in the figure, in which A and B represent the barns, this principle of arrangement is observed.

Where a thrashing-machine is employed, and upon such a farm as we are now considering, we may proceed upon that supposition, the barn for thrashing consists of two apartments, the one above the other. In the upper apartment is placed the unthrashed corn, as it is brought from the stacks. The sheaves are carried up to it by means of any easy gangway on the outside, or thrown into it from the carts by a wide door. At one end of it is the thrashing-machine, which extends down to the lower apartment. In the upper apartment is placed the table on which the sheaves are spread out, and the feeding-board at which the man stands who feeds in the corn. Below this apartment is that part of the barn termed the dressing-barn, into which the grain is received from the thrashing-machine, and where it is winnowed and prepared. Turning to Fig. 45, which represents the thrashing-machine, the space at N N is that which corresponds with the upper apartment of the barn; that at O O with the lower part or dressing-barn. In Fig. 214, A is these parts of the barn, and connected with them is the house *x*, for the moving power which we may suppose to be steam.

Connected with these apartments is a long building, termed the straw-barn. In this the straw is received as it falls from the

machine, and is piled or stored for use. This building should be of sufficient size to contain the produce of two stacks, or more. To allow sufficient space for this purpose, it is better that there be no loft or granary in this apartment, but that the whole space, from the floor to the roof, be left free. In the figure B is the straw-barn.

Adjoining the thrashing-barn should be a granary, for the purpose of holding corn and seeds of all kinds. On no large farm can a granary be dispensed with. It is usually an upper apartment, and may extend over any convenient portion of the building near the corn-barn. In the design in the figure, it extends over the shelter-sheds, C, C, C, C.

The Shelter-sheds are sheds which have yards in front. In these yards are placed moveable racks (Fig. 200 or 201) for holding the straw, or other dried provender, which the animals receive ; and there may be some fixed racks, for holding hay. There are further placed in the yards troughs of wood or stone for containing the turnips or other roots given to the stock ; and in every yard there should be a trough for containing water. In Fig. 214, *t t t t*, &c. are the troughs for containing green food ; *u u u u*, &c. the racks for hay.

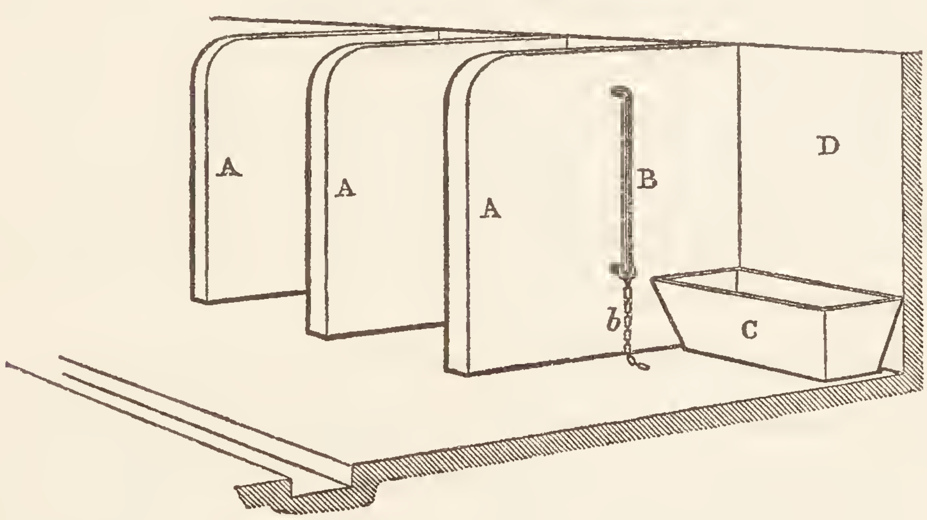
The Cow-houses should be laid out with attention to ventilation and cleanliness. They should be causewayed, with an open channel behind the animals, having such descent as to carry off the liquid.

The common method of attaching cows in these houses, is to upright posts placed in a row, at the distance of about two feet from the wall. Round each post is a moveable ring, to which is attached a chain which passes round the neck of the animal. When attached in this manner, a space of four feet between each post will suffice. The space seems to be confined enough, and yet experience shews that large cattle may be confined in a still narrower space, without apparent inconvenience. The animals feed from a low manger, formed for the most part merely by a raised ledge of stone six or eight inches high, between which and the wall the food is placed. Sometimes there is a narrow pathway between this manger and the wall of the building, by which

the food can be more easily placed before the animals: and this is a convenient and proper arrangement, though it increases somewhat the expense of the building, by enlarging the size of the roof.

Sometimes a yet more perfect system is adopted. Each cow, or pair of cows, has a separate stall, the stalls being divided by low partitions formed of flat stones or boards, of just sufficient size to keep the cows from interfering with one another. To these partitions are fixed vertical rods or bars of iron, moving upon each of which is a ring, to which is attached the chain which passes round the neck of the animal: and, further, these stalls are divided by low partitions from the pathway along which the food is conveyed. The following figure represents this method of construction.

Fig. 215.



Here A A A are the partitions between the cows; B, one of the upright iron rods, to which are fixed the ring and chain *b*; C is a manger; D is the partition separating the manger from the pathway by which the food is conveyed to the several stalls, the food, of whatever kind, being thrown over these partitions into the mangers. The same species of stalls may be applied to the feeding of oxen.

In Fig. 214, the cow-house D is placed next to the barns, and shews the arrangement of stalls here described. There is a yard in front, into which the cows may be turned out for a short time in the day for air and water, and in which their dung and soiled litter are deposited.

The fattening oxen may have houses of the same construction. But oxen may also be fed in little yards, and sheds attached to which they can retire; and this is an improved method of feeding even the finest and largest oxen. In each yard there should be a trough for holding the turnips and other food. Where turnips alone are used, no water is required; but where dry food is employed, water should be in every yard. In the figure two ranges of these sheds are shewn, E E E E E, &c. being the sheds, *eeeee*, &c. the yards. One of these sheds and yards, F *f*, may be used for holding the bull: another, J, made into a house for calves receiving milk. Should close houses and stalls be preferred, these may be substituted, the arrangement of the other buildings remaining as before.

Connected with the cow-house and feeding places, there may be a house for steaming or boiling food. A convenient position for this house is H, as shewn in the figure. Adjoining to this may be a house I, for containing potatoes and other roots; and it is convenient also where turnips are employed in feeding, to have sheds, in which a certain quantity of turnips may be put for present use. In the figure, G represents a convenient position for these sheds.

The stables must be of a size sufficient for the number of horses employed in working the farm. Each horse should have his own stall. There should be a range of racks above for holding hay, and a rack with a sparred bottom below for holding green food, as tares and clover, and a manger for holding corn and steamed food. It is proper, for the thorough ventilation of a stable of this kind, that there be no hay-loft above, but that the whole space to the roof be left free.

Connected with the stables, may be a house for holding hay for present use. In this is kept a store of hay, to prevent the necessity of going constantly to the hay-stack, when hay is wanted; and this method of keeping it obviates any necessity for a loft above the stables. In the figure, M is the hay-house, and L L the stables on each side of it.

Besides the stables for the work-horses, there ought to be on

every considerable farm a stable with a few stalls for saddle-horses. Every occupier of a large farm must have a horse, as essential to economy of time in his business, and there should be a spare stall or more for young horses in the course of training. In the figure, N is the saddle-horse stable. In the figure are further shewn a spare house for a mare and foal *l*, and a shed *m* for colts, open to the yard *n′* ; in which yard or in an adjoining one, *n*, is also deposited the dung from the different stables.

One of the necessary houses of the farm is a shed for holding the implements. This is made of a size to contain the carts, ploughs, and other implements, when not in use. In the figure, O is the Cart-shed.

On every farm there should be sufficient accommodation for the swine. The houses for this purpose should consist of little sheds opening into small yards. These may be disposed in any part of the range of buildings which shall be convenient. In the figure *h h h h*, &c., are the sheds, and *h′ h′ h′ h′*, &c., the yards in front: but the number may be extended to the degree required.

A poultry-house or two with yards may also be erected, one for the gallinaceous, and one for the web-footed, fowls, though one house and yard properly arranged will suffice. In the figure, KK are the poultry-houses, and *k k* the yards.

On a considerable farm, too, there ought to be a small locked house for holding tools, as saws, planes, hatchets, and the like. This not only preserves these smaller implements, but keeps them in one place, and prevents loss of time in searching for them. Q, in the figure, is the Tool-house.

On any large farm, it is also convenient to have a carpenter's and blacksmith's shop, at which workmen may be employed when required. A good deal of time will be saved by these means, when the blacksmith and carpenter reside at some distance. In the figure, P is the carpenter's shop, S the smithy, and R a small house for containing coals.

On a large farm, too, there should be one or more spare rooms, there being many little things to be done upon a farm which cannot be classed under any general kind of work, and for which it

is convenient to have separate apartments. In the figure, the spare rooms are marked T and V. It may be well, too, that a trusty person reside at some part of the range of buildings.

An important point to be attended to, is to convey the necessary supply of water to the different yards. When the supply is obtained in sufficient quantity from a running stream, little difficulty exists in conveying it to the troughs in the yards and other parts of the buildings. But when water must be raised from a well, it should be conveyed in the first place to a large cistern, raised to the necessary height, so that it may be brought from this cistern in pipes to the smaller cisterns or troughs. The supply can be nicely regulated by means of ball or floating cocks in the troughs, so that none of it shall be wasted. In the figure *i i i i*, are the troughs in the larger yards. There should be similar troughs in other parts, as one in the yard *n′* for the colts, one or more in the yard *d* for the cows, and, when the oxen are fed on dried food, a number to supply each of the yards, *e e*, &c.

Another object not to be neglected is to convey away the surplus liquid of the stables and feeding-houses. This may be done either by drains under ground, or by open paved channels, and these should lead to a common sewer or discharging conduit, which should be of sufficient height and width to allow a person to go up it and clean it. This general conduit should lead to one or more tanks or basins to which the liquid may be conveyed. Either this liquid may be pumped up from the tanks, and conveyed in barrels to the ground to be manured, or the tanks may have earth, litter, and other substances placed in them to absorb the liquid. The direction of the large sewer is shewn by the line *v v*, in the figure, and is laid out on the supposition of the ground being flat. Should it be otherwise, it must be laid out to suit the inequalities of the surface. The letters *y y* shew the situation of the tanks.

These various buildings, it is to be kept in mind, are designed for a farm of the larger class, and where the accommodation is supposed to be complete. When the farm is smaller, not only may the different buildings be diminished in size, but several of

them may be dispensed with. It is to be observed, however, that although on a smaller farm the same accommodation is not required as on a large one, yet the buildings cannot be reduced in proportion to the diminished size of the farm. Small farms, accordingly, always require a greater comparative extent of building than large ones. The buildings, too, of which this general description has been given, are designed for a farm partly employed in breeding, and partly in feeding. Deviations from the general design, therefore, will be rendered necessary, in the case of peculiarities affecting the mode of management.

Thus, a farm where the main purpose is the dairy, will require increased accommodation for the milch-cows, and less for other kinds of cattle. The chief object of attention in a dairy farm being the milch-cows, the accommodation for them should be commodious and complete. Ventilation, cleanliness, and water, are essential to the health of animals so much confined as the cows of a dairy. The dairy itself, or the houses for preparing the milk, should be at some distance from the cow-houses and effluvia of the yards, and either connected with, or very close to, the dwelling-house.

When a farm is near a large town, the buildings must be suited to this peculiarity of situation. On such a farm, the rearing and feeding of live-stock may not be carried on at all, and only the raising of vegetable produce for sale attended to. The buildings required for such a farm need be few and simple. No feeding and shelter-sheds are required, and there is no need of that extension of the range of buildings which is necessary in the case of a rearing and breeding farm.

Another class of farms, again, may be purely stock-farms. On this class, comparatively few buildings are required. These are principally sheds for shelter to the young cattle, and low sheds with yards for penning sheep when occasion requires. There should be a spare house or two for different purposes, as for holding wool, the extent and nature of which will depend entirely upon the kind of farm.

Besides the out-houses of the farm, there are required a dwell-

ing-house for the farmer, and houses for his labourers. The farm-house, in extent and accommodation, must generally be suited to the circumstances of the occupier; and the labouring man, when he resides upon the farm, should possess, in so far as his cottage is concerned, those decencies and comforts which are suited to his condition.*

2. Artificial Divisions of the Farm.

Where a country is entirely in tillage, it is of less importance that farms be divided by artificial barriers; but wherever live-stock is kept, this is essential to the proper keeping of the animals, and to the profitable occupation of the grounds; and besides the purpose of retaining and separating animals of different kinds from one another, and of defending the cultivated crops from injury, fences serve the purpose of sheltering the fields, and, when accompanied by ditches, of draining the ground.

The fences of the farm may consist either of stone-wall or of live-fence, or of a combination of the live-fence and stone-wall, and sometimes even of an open ditch, a mound, or a rail.

The stone-wall may either be formed of stones built without cement, or it may be built with mortar like common masonry. But the last of these methods is rarely practised with the common fences of a farm. The cementing of the stones with mortar adds, indeed, to the durability of the wall, but then the expense is too great in common cases. The wall, therefore, for the ordinary purposes of the farm, may generally be built of stone alone, though sometimes with a little mortar merely for cementing the coping, and occasionally for pinning or closing the interstices of the outside. When stones cannot be obtained, brick may be substituted.

The materials for building the dry-stone wall, as this kind of wall is termed, may be sandstone, whinstone, or any other stones of sufficient durability. Loose stones taken from the surface,

* For details regarding the construction of farm-buildings, accompanied by an ample series of designs suited to the different classes of farms, see the Author's Work on "Landed Property and the Economy of Estates."

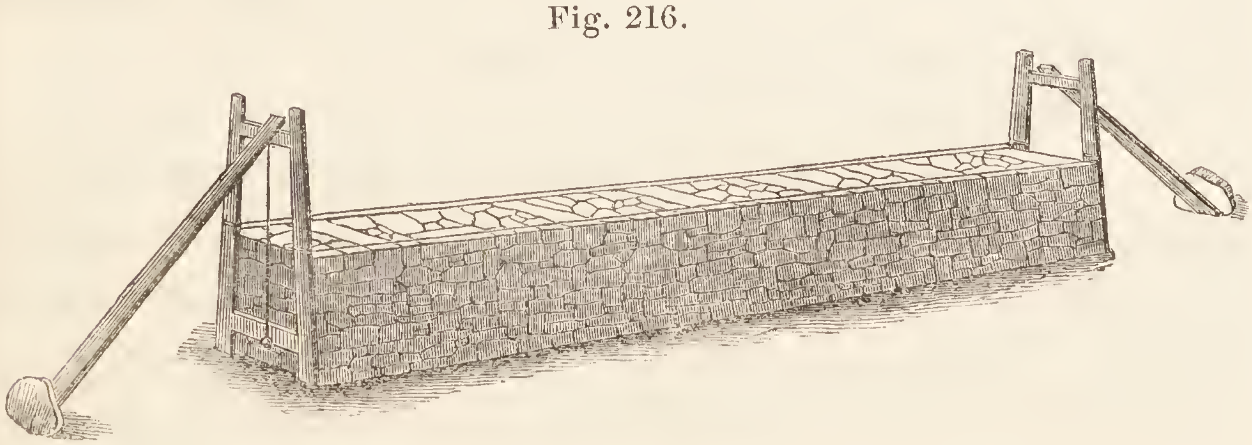
termed land-stones, answer sufficiently well, if they be of proper size, and not too much rounded: but in the latter case, they present too smooth a surface, and cannot be kept in their places without mortar.

The implements to be used in building the dry-stone wall are, a mason's hammer, a spade or shovel for clearing the ground for a foundation, a pick or mattock, and a frame of two upright posts fixed together, so as to correspond with a vertical section of a portion of the wall. (Fig. 216.)

The line of the intended fence being fixed upon and marked on the ground, the stones for building should be brought forward, and laid down on both sides, if possible, of the line of fence, but if not, on one side.

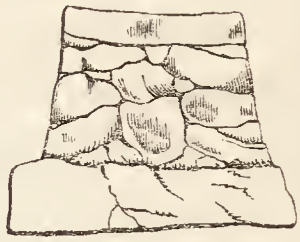
Pins being fixed in the centre of the space to be occupied by the wall, the workman proceeds thus:—He carries his wooden frame to some distance along the line to be built upon; he sets it perpendicular, which he is enabled to do by means of a plumb-line attached to it, and he fixes it in this position in a simple manner, as shewn in the figure. He then fixes another similar frame at the place where the wall is to commence; he stretches two cords between these two frames on the outside, and as these cords correspond with the outside of the wall at a given height, he has a guide for building it of the required dimensions. After having built one portion, he uses only one frame, the wall itself serving afterwards the part of a frame; for the cords being fixed to both sides of the wall, and then attached to the frame, which is placed in advance, the workman has, as before, a guide by which he proceeds in building.

Fig. 216.



The foundation of the wall should be laid on firm ground, and when there is not green sward to build upon, the loose earth should be taken out by the spade, until a solid foundation is arrived at. In building, the largest and flattest stones should be used for the foundation; and it is very desirable, if the materials used will allow, to place stones at intervals of sufficient size to lie across the breadth of the wall, so as to bind the wall together, and render it more secure. (Fig. 217.)

Fig. 217.



Different kinds of coping may be placed upon the wall, to defend it. One of these consists merely of turf, two sods being laid upon the wall, with the earthy sides placed towards each other. Another species of coping consists of large stones, which, being closely built and wedged together, are cemented by mortar. This is a complete and durable species of coping; but when it is used, a row of flat stones should be laid on the top of the wall immediately beneath the coping, and made to project a little on each side of it. (Fig. 218.)

Fig. 218.

A wall, sufficient for the purposes of the farm, may be 32 inches wide at bottom, 16 inches wide at top, and, including the coping, 4½ feet high. Such a wall, exclusive of the expense of procuring and bringing forward the stones, may be built at from 4½d. to 5d. the yard in length, at the present rate of labour in this country; and two good cart-loads of stones will suffice for building a yard.

The advantages of the stone-wall as compared with the live-fence, are, that it becomes useful as soon as made; that it can be formed in situations so unfavourable with respect to soil and climate, that the thorn and other plants cannot be raised; that it requires no nursing, nor the other expenses of cleaning and pruning which attend the live-fence; that it is not injured or destroyed by the trespasses of sheep and other animals, as the live-fence

frequently is in the early stages of its growth; and that it occupies little room, and does not injure the growing crops, by harbouring birds and other animals. For these reasons, there are many cases in which the stone-wall is the best species of fence. It is in an especial degree suited to an elevated country. Nothing, indeed, is more to be desired in such a country than to obtain shelter; and live-fences, where they can be reared, afford a certain degree of shelter, by breaking the force of winds. But as live-fences grow for the most part feebly in very elevated situations, they there perform but imperfectly the purposes of shelter. In such cases, shelter is better obtained by the planting of wood, which is superior to fences in affording the means of improving the climate of a bleak country.

But, again, the live-fence, accompanied with ditches, has its advantages in the situations where it can be reared. Not to speak of it as an object of beauty, in which it far surpasses the stone-wall, it affords shelter, and, in combination with the ditch, the means of carrying off water from the ground.

For this kind of fence, different plants of the Rose family are employed. These are armed with sharp spines, and, branching out in innumerable directions, form dense bushes. Of these plants, the most esteemed is *Cratægus Oxyacantha*, the Hawthorn.

The hawthorn is easily produced from the seeds of its fruit or haw. It is best raised in the nursery, and, after being two years transplanted from the seed-bed, in the manner of forest-trees, planted in the line of the fence.

The ground upon which thorns are to be planted, should undergo a complete preparation by deep ploughing, or trenching with the spade, and by a thorough manuring. Attention to this preparation is very important, and will, in many cases, constitute the difference between success and failure in forming a thorn-fence. When the ground is tolerably full of vegetable matter, lime may be used as a manure. But where the soil is poor, both lime and dung should be employed, and it is generally advantageous to apply them twelve months or more before the thorns are planted.

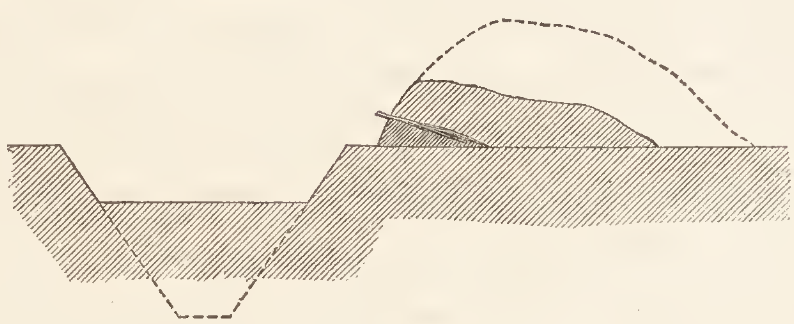
Having fixed upon the line of the fence, it may be laid off by means of poles, like the ridges of a field, and marked upon the ground. The instruments used in the practical operation are a common reel and line, like that of gardeners, and a rod of wood of about 6 feet in length, divided into feet and inches, with a piece of wood fixed at right angles to the end of it, so as to measure off with facility the breadth of the ditch, in a direction perpendicular to the line laid down. The instruments for working are a common spade, a narrow-pointed shovel, a common mattock, and a foot-pick.

The line of the side of the ditch along which the thorns are to be set, being marked out by the rod and line, and notched by the spade, the workman takes off a part of the earth from the surface of the intended ditch, and lays it along the future line of thorns, this earth being generally laid a few inches back from the notched line, so as to leave what is called a scarcement; or, if there be sward, a row of sods are in like manner to be laid a few inches back from the notched line, with their grassy sides undermost. He then beats down the earth or sods thus laid with his spade, so as that the outer surface shall be in the line of the future mound, and sloping a little backwards in the manner shewn in the following figure, so that they shall be highest next the ditch. It is upon the row of earth or sods thus placed, technically termed the thorn-bed, that the thorns to be planted are laid. A further portion of the surface of the ditch is then stript off, and thrown behind the thorn-bed.

The thorn plants have, in the mean time, been prepared in the following manner:—Each plant, with its roots and fibres as taken out of the ground, is grasped by one hand, while, with a sharp knife, the stem is cut through by a cut inclining upwards, so as to leave, exclusive of the root, about 8 inches of the stem. The plants being thus prepared, may be put in the earth again until they are ready to be planted. This is done that they may be protected from frost, for the process of planting being performed in winter, every precaution is to be employed to prevent the young plants from being injured.

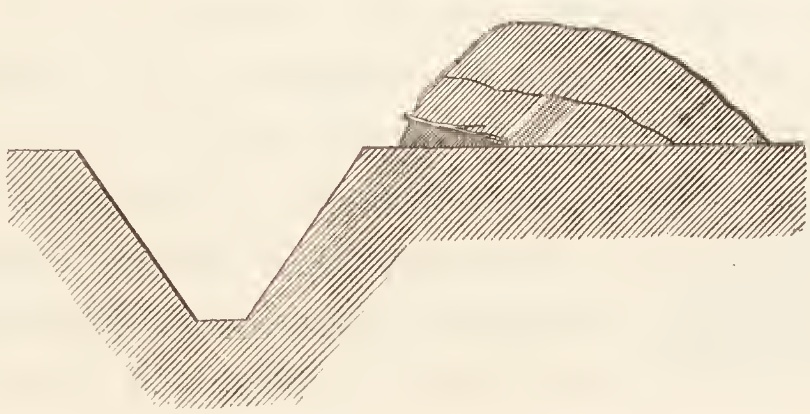
When a sufficient space of ground is ready for being planted, the plants are to be placed firmly upon the thorn-bed, so that, when the mound is made, they may project a very little beyond the surface, or rather just reach it. The distance at which they may be planted from one another, may be about 8 inches. While one or more persons are employed in laying the thorns, another is to shovel up from the ditch the loose mould immediately next the surface, and place it upon the stems of the plants. This earth being compressed by the foot, the plants will be firmly fixed in their position, and so covered as to be out of the reach of danger from frost. A section of the bank will appear at this stage of the process, as in Fig. 219.

Fig. 219.



A considerable portion being done in this manner, the ditch is to be cleared out to its full depth, and the earth thrown upon the bank. The mound is then to be rounded at top, and beaten all around by the shovel. A transverse section of the work when finished will appear as in Fig. 220.

Fig. 220.



This completes the formation of the hedge and ditch. The ditch should be narrowed to a spade-breadth at bottom, and the sides made to slope at an angle of 45°. The mound will occupy a somewhat larger space than the breadth of the ditch. The ditch must be so laid out and formed, as to permit the descent of water. Where there are slight inequalities, it must be made deeper at one part than another, and if necessary, the earth must be wheeled away from the part where the ditch is deep, to make up the mound where the ditch is shallow; and sometimes, in the case of passing a hollow place, the water must be carried away by a drain, cut through the mound and underneath the thorns into the adjoining field.

It is a very common practice in making the ditch and hedge, to leave a scarcement or little space between the thorns and the edge of the ditch; but some do not approve of this scarcement, conceiving it to be unnecessary, and to favour the growth of weeds. The advantage, however, of leaving the scarcement is, that it tends to prevent the earth from falling down into the ditch, and leaving the roots of the plants exposed.

The proper time for performing the operation of planting, is from October to the beginning of March, that is, during the period when vegetation is inert.

Following the practice that has been described, failure will be rare, except in situations entirely unsuited to the growth of the thorn. The plant, it will be seen, is set on a mould in the manner best suited to favour its growth: and the stem being laid nearly horizontal and covered with earth, it shoots forth fibres at every part, and becomes itself a root.

In place of one mound and ditch formed in the manner described, two ditches are sometimes formed, with a mound between, and two rows of thorns. This kind of fence, however, is only mentioned that it may be condemned. It occupies more room than the single mound, creates nearly double the expense of management, and is not so favourable to the growth of thorns. The only case in which a double row of thorns and ditch of this kind

should be formed, is in hollows, where two ditches are required for carrying off water.

The fence, then, as described, is a mere bank of earth with a ditch, which animals can pass over. In its first stage, it forms of itself a feeble barrier, and is subject to be destroyed by animals passing over it. It must, therefore, be defended until it becomes an effectual barrier; and this is done by means of rails or paling.

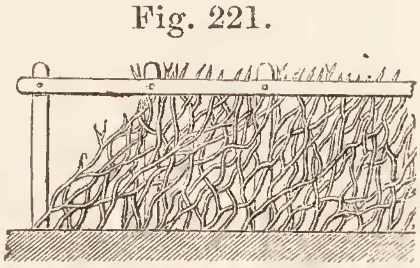
Paling consists of horizontal rails, nailed to posts or stakes, placed vertically, and driven into the ground. It may be made with either two or three horizontal rails. The latter number is preferable, and necessary where sheep are feeding.

The rails are formed either of sawed or split wood. When the trees are small, they may be split, but when they are of sufficient size they should be sawed. Wild pine, spruce, larch, or any other of the fir or pine kinds, will answer; and the quantity of these trees in all parts of the country is now so great, that they can be everywhere obtained with facility, and at a low price.

Of the same material the stakes are formed. These are made about $4\frac{1}{2}$ feet long, and sharpened to a point. They are driven into the ground with a mall to the depth of about 15 inches, and set at the distance of 5 or 6 feet from one another. The horizontal rails are attached to them by stout nails.

Another species of temporary fence, which may sometimes supply the place of paling, is formed in the following manner: —Posts or stakes, as for paling, are driven into the ground, and branches of trees, or brushwood of any kind, are warped or wattled round the stakes. The but-ends of these branches are placed upon the ground in warping them, and an inclination is given to them as in the figure. A light spar along the top will render this species of fence very complete. It will last as long as paling, and is more economical, since the bushes and branches are of little value.

Fig. 221.



One set of paling will generally last sufficiently long to allow the fence to attain to the necessary height and strength. It is to ensure this that the paling should not be put up sooner than is really required; so that, if the land be under a course of tillage, the paling need not be put up until it is again laid down to grass.

The rails for the protection of the fence may be placed upon the top of the mound. This forms an effectual barrier, in so far as it prevents animals from passing over; but it does not prevent animals that may be pasturing on the thorn side of the field from reaching the young plants. They will rarely, indeed, do much injury, unless they pass over; but all injury may be guarded against, by placing a row of paling along the edge of the ditch itself, so as to prevent access to it. In this way, indeed, there are two rows of paling, which increases the expense; but these rows need not in this case have each more than two bars, and if it is important to rear an efficient fence, without the risk of failure, it may be better to do the work in this manner. For the most part, however, when there is a good ditch, one row of paling of three bars on the top of the mound will be found sufficient.

The hedge, mound, and ditch being formed, there is next to be considered the manner of managing the fence. The implements required for this purpose are, first, those for weeding, and, secondly, those for cutting or lopping the branches or twigs.

For the first of these purposes, that of weeding, a simple instrument will suffice, namely, a small spade, usually termed a hedge-spade, with a handle about 3½ feet long, and a blade about 5 inches broad (Fig. 224).

The instruments used for lopping or cutting may be three: The first is a slightly bent knife fixed to a handle, for cutting off the ends of the twigs or branches by an upward stroke (Fig. 223); or in place of this may be employed shears; but the knife is equally efficient, and more expeditious.

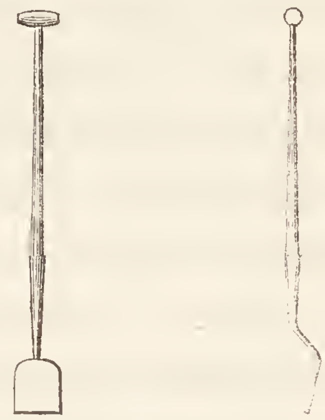
The next instrument is one of the same form, but of greater

weight, and with a shorter and more slightly curved blade (Fig. 222). This instrument may weigh about 6 lb.; it is employed for cutting through the stems of thorns. The other instrument is a light axe, which is employed for the same purpose.

Fig. 222.

Fig. 223.

Fig. 224.



The first object of attention, after the thorns are set, is the young plants, which, we have seen, have been buried in the ground, with one end just projecting to the surface. These will generally pass through to the day when they have begun to grow; but should they not be able to make their way through, the earth is to be gently stirred with the hand or a stick, so as to open a way for them, taking care, however, not to rub off any of the buds.

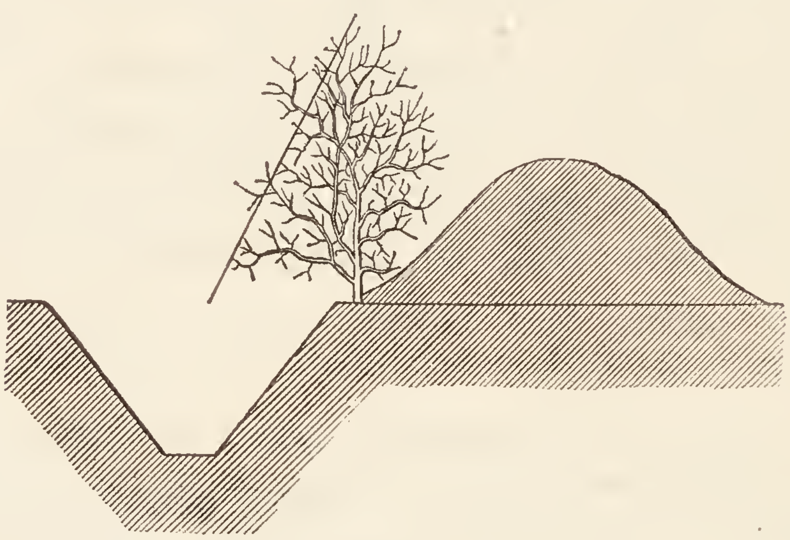
During the first year of their growth, the plants will require little cleaning, and no pruning. Should weeds, however, spring up in quantity in the first year, they must be hoed down. The manner of hoeing is simple: The hedger, with his small spade, stands in the ditch, and with light horizontal strokes cuts down the weeds about the thorns. He may also, if necessary, proceed along the top of the mound, and, working downwards, cut such weeds as he may not be able to reach from below. After this, the same process of cleaning should be performed at least once every year, and generally twice. The work may be done at any period in the year when the weeds are growing; but when the fences are young, it is a good rule to perform the operation before the weeds rise in summer amongst the twigs of thorns.

The weeds that infest hedges are grasses of different kinds, of which the most troublesome and difficult to be extirpated is couch-grass. Other plants, as docks of different kinds, thistles, and chiefly the way-thistle, chick-weed, and dead-nettle, goose-grass, common rest-harrow, wild mustard, tufted vetch, and many others, form the common weeds of hedges.

The other process in the management of the hedge is that of pruning. This is intended to cause the plants to grow bushy and thick, so as to form a barrier to animals. It is simply performed by means of the light knife (Fig. 223).

During the first year of the growth of the hedge, it will require, it has been said, no pruning; the second year, after the fall of the leaf, pruning may be begun; and it is to be observed, that in all cases of pruning, the proper season is when vegetation is inert,

Fig. 225.



and not when the sap is ascending. The thorns at this stage are to be pruned lightly, with an upward stroke of the knife, a small portion also of the shoots of the top being lopped off. The same process is to be annually repeated, keeping the whole narrow at top, broad near the bottom, and inclined from the bottom upwards in the manner shewn in Fig. 225.

When the thorns, under this system of yearly lopping the lateral branches, and slightly cropping the top, have reached the height of 4 or 5 feet, two methods of management may be adopted. Either the whole may be allowed to grow to the height to which

it will naturally grow, the only further pruning being to cut off such of the lateral branches as are overshadowing those beneath; or the process of pruning may be continued yearly, so as to keep the hedge at the proper height, namely, 4 or 5 feet.

This, then, is the simple management of the thorn fence:—It is, or ought to be, every year weeded once or twice; and it is to be regularly pruned, so as to render it bushy, until it gets to a certain height, when it may either be allowed to grow up to its full size without further pruning, or be kept by an annual pruning at a uniform height. The former method is sufficient with the fences of a farm, but the latter makes the neater and more bushy fence, although it is the more expensive.

Under this management, the fence will continue vigorous for a long period. But when at length, from any cause, it gets thin at the root, or shews symptoms of feeble growth, or when, having reached its natural size, the lower lateral branches begin to fall off, a simple method of renewing it is to be practised.

In this case, the whole thorns are to be cut down to within a few inches of the ground, employing either the heavy cutting-knife (Fig. 222), or, when the stems are very strong, the axe.

In employing the cutting-knife, the hedger stands in the ditch with his right hand towards the thorns, and cuts upwards with a back stroke with his right hand. The stroke must in all cases be made obliquely upwards, and not downwards; for the effect of the latter method would be to shatter the lower part of the stem, and subject it to injury from wetness. When the axe, instead of the knife, is used, the workman stands in a different position. His left hand is now next the hedge, and he uses both hands in cutting; the stroke, however, as before, being made obliquely upwards. But it is only when the stems are very thick and old, that the knife will not effect the purpose.

When the thorns are thus felled to within a few inches of their roots, the ground around the stems is to be carefully cleaned by digging; and the further operation to be performed is to clean out the ditch, and replace before and around the thorns the earth which had been drawn into the ditch by continued weeding. The

stocks of the thorns will now be nearly covered to the top. Fig. 226 shews the state of the fence before the ditch is cleaned out; and Fig. 227 when the operation is completed.

Fig. 226.

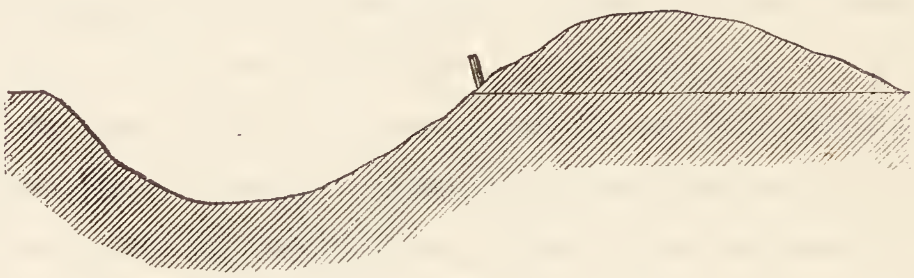
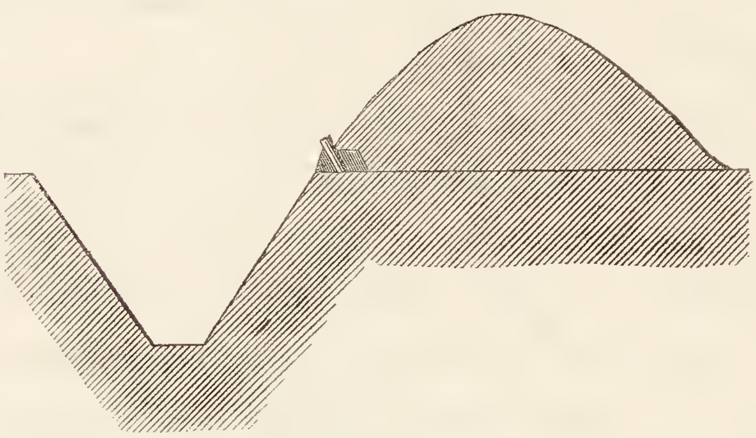


Fig. 227.



In a very short time after this operation, shoots will spring from the old stems with vigour, and thus the fence will be restored, when it will appear as in Fig. 228. There may be cases,

Fig. 228.

indeed, in which shoots will not spring from the old stocks. This indicates that the hedge has lived its natural term, and is the irremediable effect of age; but in all cases in which the hedge possesses sufficient vigour, this method of renewing it will be attended with the effects desired.

And in cases in which a thorn hedge is seen to have suffered

from previous neglect, this simple mean may be employed to restore it. In this case, also, the opportunity is taken to fill up blank spaces in the line of the thorns. For this purpose, the earth in the blank spaces should be completely taken out, and the spaces filled with fresh soil; and in place of the hawthorn, the crab may be planted, as being better calculated to succeed under such circumstances.

Instead of planting new thorns to fill up a blank, a practice sometimes resorted to is, in the second year after the new shoots have sprung up, to take one of them on each side of the gap, and, bending them down, to fix them with a crooked stick, to the ground, in the manner practised by gardeners. Some earth being then laid upon the twigs, they will soon spring up and fill the interval of the gap, especially if the earth of the gap has been filled with new soil, well dunged and limed. A gap renewed in this manner will appear as in the figure.

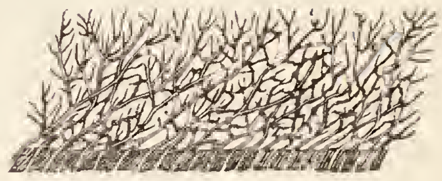
Fig. 229.

When hedges are lopped down to the ground in the manner described, they must be protected until the new shoots have attained a certain size, as in the case of new fences. But it is not usually necessary to have recourse to paling, because the thorns cut down furnish themselves material for forming a sufficient fence, termed a dead hedge.

A dead hedge is thus formed :—The workman cuts the stems of the thorns into lengths of three or four feet. He forms bundles of these, mixing with them the smaller twigs, and compressing them so that they shall adhere together. Another person with a spade, working on the line which the dead hedge is to occupy, takes up a sod or spadeful of earth ; and a bundle of twigs being handed to him, he places the but-end of the bundle in the hole made by the spade, and leaning against the earth thrown out. He then lifts another sod or spadeful of earth, and places it upon the but-end of the first bundle, compressing it firmly with his foot; and in this manner he forms the line of the fence. The

fence, when finished, appears as in the figure; and a proper situation for it is on the mound immediately behind the thorns.

Fig. 230.



The plant which has been especially referred to as calculated for the hedge, is the hawthorn. But there are two other plants, similar in appearance, which are sometimes cultivated, either separately or intermixed with the hawthorn. These are, *Prunus spinosa*, the Sloe, and *Pyrus acerba*, the Wild Apple or Crab. Both of these plants grow readily, and bear cutting; but they are not so well suited for cultivation for hedge-plants as the hawthorn.

A plant sometimes cultivated for hedges, though destitute of spines, which so particularly fit the hawthorn for its purpose, is the Beech, *Fagus sylvatica*, which forms a tolerably good fence, from the mass of twigs which it sends forth when it is restrained in its upward or lateral growth by pruning. The Hornbeam, too, *Carpinus Betulus*, is equally well suited for the hedge as the beech, and is sometimes cultivated for that purpose.

The properties which fit the beech and the hornbeam for the hedge are, the facility with which they can be produced, the manner in which they bear pruning, and their fitness to grow on land somewhat low in the scale of fertility. Sometimes the beech is mixed with thorns, every second or third plant being a beech. Good fences may be produced in this way, but, in general, the simple thorn is the best defence against cattle, and an intermixture of other trees and shrubs injures its utility. The beech and the hawthorn being of irregular growth, and the beech the most rapid, the latter tends to prevent the growth of the thorns, and often extirpates them altogether.

The Alder and the Willow form tolerable fences on marshy ground, and grow on soils where the hawthorn could not be produced; and they may thus, in some cases, be beneficially substituted for the thorn. They may be twisted together, for which their pliable branches peculiarly adapt them.

The Holly, *Ilex aquifolium*, has in some cases been substituted for the thorn. It makes an impenetrable fence, bears cropping well, and its verdure does not suffer in the severest winter. The objections to the culture of this hardy plant are, the slowness with which it grows, and the difficulty of raising it. The holly, indeed, does not grow so quickly as the thorn, but yet it can be raised in many situations, if proper care be bestowed. Not bearing transplanting well, it may be raised from seeds on the spot where it is to grow.

Another plant, indigenous, easily cultivated, and growing even on moors, armed too with spines, and an evergreen, will suggest itself as a fitting plant for the hedge: this is the Common Whin or Gorse, *Ulex europæus*.

A hedge of whin may be formed thus:—A mound is to be made 6 feet wide at bottom, 20 inches wide at top, and about 6 feet high. Each side is to be built firmly with sods, taken from the spot, the middle is to be filled up with loose earth, and the top rounded over. A shallow ditch is to be left on each side of the fence with an interval or scarcement of 10 or 12 inches between the ditch and wall of sod. The whin-seeds are to be sown along the top of the mound, while the earth is yet fresh and moist. A pound of seeds will sow about 200 yards, and the best season for sowing the seeds, and consequently for making the fence, is during the months of March and April. This species of fence becomes complete in the second year after it is made, and therefore requires no rails. The whins should be pruned once every year: upon attention to this the success of the hedge mainly depends; and the proper period of pruning is in the month of June. The whin-hedge formed in this manner, is one of the cheapest fences that can be made. The roots of the whins will penetrate through every part of the mound, and prevent it from crumbling down, and the dense bush, formed at the height of 6 feet, will be sufficient to prevent the wildest sheep and cattle from passing over.

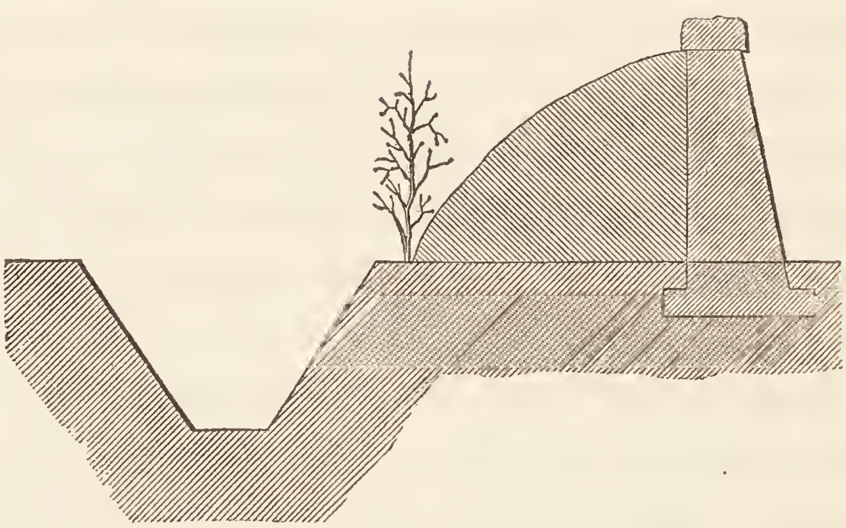
With this facility of growth, cheapness of production, and seeming fitness of the plant for its purposes, it will reasonably be in-

quired why it is that the whin is so little used as a hedge-plant in this and other countries. The chief reason is unfortunately a good one—its want of durability. Although a native plant, and under certain circumstances, hardy, it is very apt to be destroyed by frost. It cannot, therefore, be depended upon as a permanent fence. Its duration indeed can be greatly prolonged by regular pruning, but under the best management, the whin is comparatively of short duration as a useful fence. When, however, a cheap, and immediate fence is required, without especial regard to the time it is to last, the whin will answer the purpose well.

The fences described are the stone-wall and the live-fence; but sometimes the two may be combined together, and form efficient fences.

The most common of these is formed in the following manner:—A mound and ditch are to be made in the way already de-

Fig. 231.

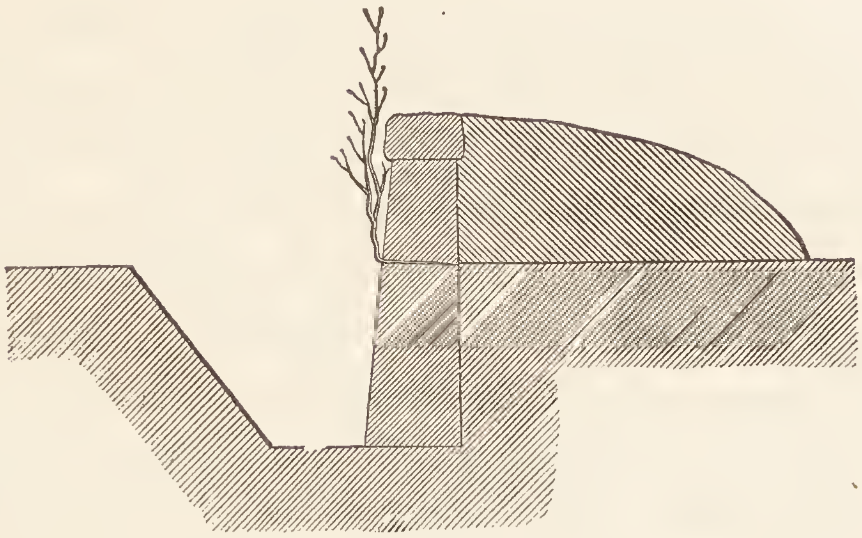


scribed, but the one side is to be a wall of stone, of half the breadth of a common wall, and $4\frac{1}{2}$ feet high, as shewn in the figure. This fence is therefore secured on one side, and requires only a row of two-bar paling on the other side to secure the hedge in its young state.

Another species of combined fence is what is termed a sunk fence, faced up with a dry-stone wall, as in the following figure. The base of the wall is 2 feet, and on the top is laid a coping of

turf of $1\frac{1}{2}$ foot thick. The thorns, when the wall has reached

Fig. 232.



the proper height, are laid horizontally, and the stones so built that there shall be an aperture for each thorn at the distance from one another of 9 or 10 inches. The thorns laid in this manner will shoot through the apertures between the stones. This kind of fence is suited to situations in which one side is safe from trespass, as round plantations; and, as a security against any animals attempting to scale it, whins may be sown along the top of the mound.

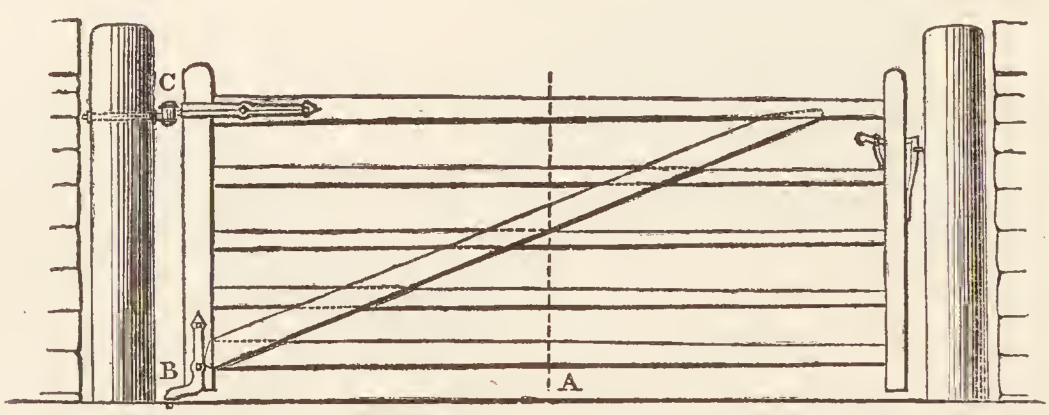
Another point to be considered with relation to the fence is the Gate. The properties of a good gate are, that it shall combine with lightness the necessary strength, so that an equal quantity of materials shall produce the strongest gate. The strongest gate would be a solid piece of wood like a door, but this would not fulfil the other condition of lightness. Instead of the solid mass of wood, a set of horizontal bars will fulfil the purposes required. These bars must be at such a distance from one another as to prevent the passage of animals, and so connected as to be firmly bound together.

In the gate represented in the figure, there are five horizontal bars, connected together by a diagonal from the lower to the higher corner. This construction, it is conceived, will fulfil, sufficiently near for practice, the purpose of giving the parts of

the gate the greatest strength with a given weight of materials. Sometimes upright braces are nailed to the gate, but these are not essential.

The gate may be hung upon two hinges; or the heel of the gate may rest in a socket placed in a stone on the ground, as in the figure. The bars should taper towards the fore part, so as to be lightest there, which diminishes the tendency of the fore part to fall down. For a gate, when we regard its tendency to sink down at the head, may be considered as a bended lever, of which the fulcrum is at B, the power at C, and the weight the centre of gravity of the gate, which, in the case of the gate being of uniform materials, will be represented on the lower bar at A. Hence, by increasing the length of BC in proportion to BA, the power of the hinge at C to support the weight of the gate is increased; and this power is further increased when the gate is made heavier at its posterior part, so as to bring the centre of gravity nearer to B. In practice, therefore, the hinges should be kept at as great a distance from each other as possible, and the gate should be made light towards its anterior part.

Fig. 233.



In the figure there are shewn five horizontal and two upright bars. The extremities of the horizontal bars are mortised into the two outer upright bars. The diagonal consists of a plank nailed to the one side, and abutting on the upper bar; and on the other side may be nailed an upright brace. The horizontal bars taper from the hinder part of the gate to the fore part. The length of the gate may be 9 feet, the height over the horizontal

bars 3 feet 9 inches, the lower bar standing about six inches from the ground..

The posts may consist of wood, and should be well sunk in the ground; and any coarse kind of timber of sufficient strength may be employed; or, what is better, when they can be procured of the proper size, single stones of granite, greenstone, or any of the harder rocks. The band of the hinge should pass through the wood or stone, as shewn in the figure, and be fixed by a bolt or screw-nut on the opposite side.

The latch may be of various forms: that shewn in the figure is a spring of 2 feet in length, to which at right angles, as is more distinctly seen at *c*, Fig. 236, is fixed a piece of iron, which passes through the upright bar of the gate. This piece of iron, by means of two joints, acts as a lever when the hand is placed upon it, and withdraws the latch.

Sometimes it is convenient that a gate shall shut of itself when opened. A good gate of this construction is represented in Fig. 234. The upper hinge of the gate is fixed to the upmost bar, and is received into a socket in the hinge, as seen at *b*, Fig. 235. The advantages of making the upper hinge move in a socket are, that while space is given to it to move, it is firmly supported in its place; and that the means are afforded of causing it to move smoothly by pouring a little oil into the socket. The lower hinge is formed upon the principle of affording two pivots or points of support to the lower part of the gate. It consists of two iron plates placed horizontally, the one a little above the other, the upper being fixed to the post and the lower to the gate. From the lower part of the upper plate project two small cylindrical pieces of iron, placed perpendicularly as seen at *a*, Fig. 235. These are received into the grooves or hollows of the under plate, so that the gate rests upon the two upright pieces of iron as pivots. The gate, when shut, has thus three points of support, namely, the socket of the upper hinge and the two lower pivots, the former of which is thus placed at the vertex, and the two latter at the base of an isosceles triangle; from which construction it results, that the gate is only in a state of equilibrium

when, being shut, it rests upon both the two lower pivots; when opened accordingly it must tend to regain its former position.

This construction, however, is not good in the case of the or-

Fig. 234.

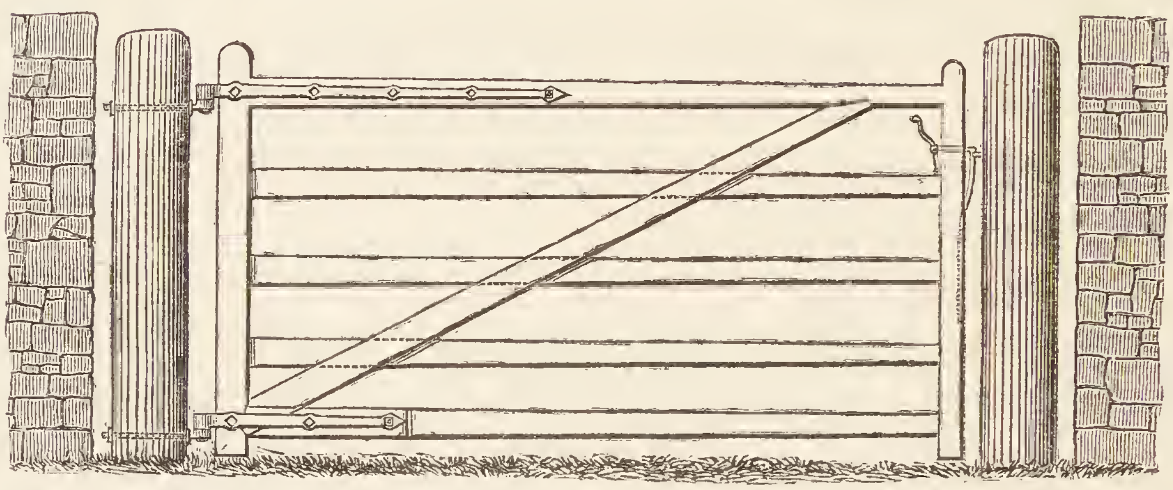
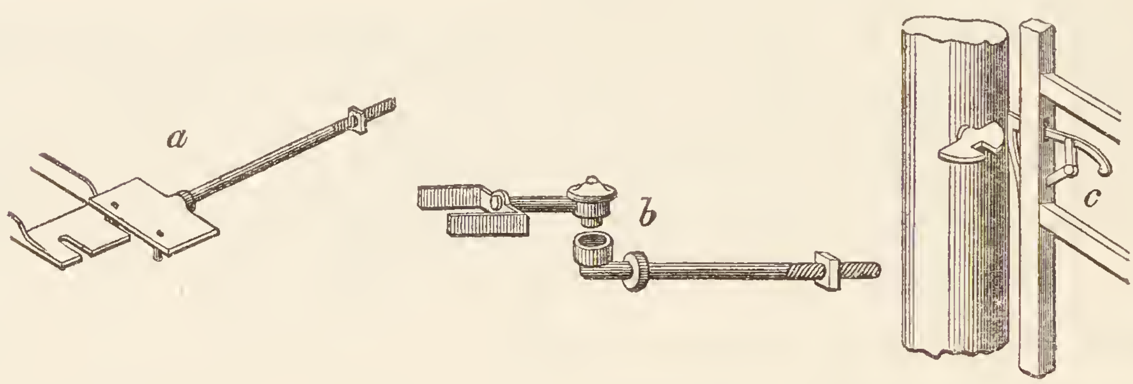


Fig. 235.



dinary gates of a farm. They are apt to be torn off the hinges by the passing of loaded carts.

All the mortises of a gate, and the parts at which the diagonal and braces cross the bars, should be carefully coated with white lead; and after the parts of the gate are joined together, the whole should receive two coats of oil-paint.

Farm-gates have sometimes been made wholly of hammered iron. The chief objection to this kind of gate is, that it is apt to be bent. The wooden gate of good construction answers its purpose as well as can be wished.*

In speaking of the fence, I have said nothing of that which we

* Further details on the construction and management of the fences of the farm, are given in my Work on Landed Property and the Economy of Estates.

are apt to associate with it, as its almost universal accompaniment, the hedgerow tree.

Were we to estimate the value of hedgerow trees by considerations of beauty alone, they would be beyond all price. Nothing gives so clothed and lively an aspect to a country as these beautiful objects; and the cultivated scenery of England is, on this account, amongst the richest anywhere seen. The taste for this species of planting in England is universal, and is rivetted by habit and the earliest associations.

The practical farmer, however, feels from experience that in the hedge the forest-tree is out of its place. Its spreading roots interfere with and destroy the thorn, and its branches overshadowing it are also hurtful; and more than this, it extends the fibres of its roots into the adjacent fields, and, the branches overhanging the corn in its vicinity, exclude the air which is necessary for the healthy growth of plants, and the labours of harvest.

If profit, and not the gratification of taste, is to be regarded, trees should be planted, not in hedgerows, where all the value at which they will arrive will rarely balance the yearly loss which they produce, but in groves, belts, or masses, where the trees will really become of value as timber, without injury to the fences and cultivated fields around. Were the loss sustained in England by the excessive multiplication of hedgerow trees to be reduced to calculation, it would exceed belief.

3. Capital necessary for the Farm.

The capital necessary for a farm is the sum which a farmer must possess, in order that he may carry on his business. This partly depends on the customary degree of credit in a country. The farmer does not usually pay ready money for all the commodities he requires, but trusts to that degree of credit which is common in his business. And the same remark applies to almost every class of traders in this country. A merchant rarely limits his trade to the extent of his ready money, but trusts to that de-

gree of confidence which exists; and in this way the greater part of the trade of this country is carried on.

In like manner, the person who enters to a farm may not find it necessary to possess all the capital which would be required were he to pay for every thing; yet the nearer his funds approach to this condition, the greater will be his security. Too many engage in extensive farming on a loose and imperfect estimate of the funds required, and find, when too late, that they have miscalculated their means.

A want of the necessary funds is often more injurious to a farmer, than even an obligation to pay a high rent. With an inadequate capital, he is impeded at every step. He cannot render justice to his farm; he must often bring his goods prematurely to market to supply his wants, and he will pay largely for the credit which he is compelled to seek. The farmer who has ready money at his command has, like every other trader, a great advantage over one who is forced to seek credit, and will be enabled to make a profit on many transactions on which the other would sustain a loss.

While, therefore, it cannot be contended that a farmer, who lives in a country where credit is the soul of commerce, is not to avail himself of this benefit, yet he must be careful not to miscalculate its effects; and, at all events, and like every prudent man, he must make himself acquainted with the real amount of his pecuniary obligations. This is the true principle on which the capital required for a farm should be computed. The sum to be determined is that which the farmer has to advance, before a quantity of produce is raised upon the farm sufficient to replace the advance, and supposing all payments to be in money.

But the amount of necessary advances differs greatly according to the nature of the farm, the mode of management to be pursued upon it, the period of entry and the time of paying rents, the manner of paying labourers, and a multitude of circumstances dependent on local practice. To calculate the amount of capital, therefore, required in any case, it is necessary to limit the calculation, not only to a certain district, with a certain set of local

customs, but to a given farm, managed in a given manner. All, therefore, that can be done, in the case of calculating the amount of capital required for a farm, is to give an example of the manner of making such a calculation under certain supposed conditions.

In the following calculation, the assumption is made of a farm where a combination exists of the practice of tillage and rearing live-stock, where two-horse teams are in use, and where a system of cultivation is pursued similar to that which has been explained in the present work.

The farm is supposed to contain 500 acres, to consist partly of clay and partly of turnip soil, and to be managed in a five years' rotation, thus:—

1st, 100 acres in corn, namely—
- 95 acres in oats.
- 5 acres in tares.

100

2d, 100 acres in fallow and fallow-crops, namely—
- 60 acres in turnips.
- 5 acres in potatoes.
- 35 acres in summer-fallow.

100

3d, 100 acres in corn, with which are sown clover and ryegrass seeds, namely—
- 60 acres in barley, after turnips.
- 40 acres in wheat, after summer-fallow and potatoes.

100

4th, 100 acres in young grass, namely—
- 28 acres used for hay and green forage,
- 72 acres used for pasture.

100

5th, 100 acres in grass in its second year, used for pasture.

500 acres.

Under this system of management, the crops will succeed to one another in the order mentioned; and the farm will every year be in five divisions, namely, 100 acres in oats, with a small quantity of tares; 100 in fallow, turnips, and potatoes; 100 in wheat and barley; 100 in young grass; and 100 in grass in its second year.

The period of entry is assumed to be on the 15th day of May with respect to the land in grass, and the land to be in summer-fallow and fallow-crops in that year; and to the land bearing corn-crops, when these are removed from the ground in autumn. This species of entry, with certain variations, prevails over a considerable part of England. The principle of it is, that the out-going tenant shall have a crop in the last year of his possession, or, as it is termed, a way-going crop; but that in the month of May of the same year, he shall give up to the entering tenant all the land in grass, and all the land which, in the regular course of management, would be in fallow or fallow-crops, and which the entering tenant, accordingly, works for his own use. The out-going tenant having sown his crop, has no further use for the houses upon the farm, and these, therefore, the entering tenant takes possession of in May.

Under this supposition, the entering tenant has no corn-crop in the first year of his possession. He reaps the first crop of corn in the second year. We may assume that this crop is not really available to him till about the middle of November in the second year, that is, till eighteen months after his entry. But the crop upon an arable farm being the chief fund of a tenant for paying his rent, and replacing his advances of all kinds, we may assume that it is not till his crop is really available, that the fund advanced by him as farming capital has been replaced. To calculate his advance of capital, therefore, we are to reckon all the charges to which he has been subjected during the first eighteen months of his possession, deducting, however, any sales of produce which may have been made during that time. These advances will be conveniently divided into classes, as Implements and Machines of the Farm, Live-Stock, &c.

(1.) Implements and Machines of the Farm.

The first calculation to be made with respect to the implements and machines of the farm, relates to the number of ploughs to be kept regularly at work in tilling it. Upon this depend the number of horses to be employed, and the number of ploughmen.

The manner of determining the number of ploughs or teams, is by ascertaining the extent of ground to be kept in tillage, and by assigning for this such a number of ploughs or teams as experience shews to be necessary for working the farm.

Under a perfect system of labour, one man works two horses; and this team will do all the labour required in the proportion of one pair of horses for every 50 acres kept in tillage. In the lighter class of soils, one pair of horses will work 60 acres; but it will be better to assume 50 acres as a medium. On the farm, then, to which the present calculations refer, 6 pairs of horses will require to be at work, there being in tillage each year three of the five divisions of the farm, that is, 300 acres. The number of ploughs will accordingly be 6, and that of harrows and various other implements will bear a certain proportion to this number of ploughs:—

6 Iron ploughs, at L.3, 15s. (Fig. 12), . .				L.22	10	0
But ploughs may be constructed partly of wood, which answer the purpose perfectly well. The expense of these will be from L.2, 16s. to L.3 each.						
6 Pairs of common harrows, at L.1, 7s. (Fig. 21),				8	2	0
2 Pairs of lighter harrows for covering grass-seeds, at L.1, 7s., . .	L.2	14	0			
Grubber (Fig. 25), . .	10	0	0			
	L.12	14	0			
But the lighter harrows for covering grass-seeds, are not indispensable, and the grubber, though a highly useful, is not an absolutely necessary, implement of the farm.						
1 Cast-iron roller (Fig. 26), . . .				10	0	0
1 Broadcast sowing-machine (Fig. 34), . .				10	10	0
Carried forward,				L.51	2	0

Brought forward,		L.51 2 0
1 Turnip sowing-machine (Fig. 38), . .		6 0 0
Besides which, the nature of some farms may require,—		
1 Machine for sowing corn in rows (Fig. 32), . .	L.10 0 0	
1 Bean-barrow (Fig. 35), L.1, 10s., or better the machine, Fig. 36, the price of which is	3 15 0	
	L.13 15 0	
2 Single-horse ploughs for hoeing fallow-crops, at L.3 (Fig. 40), ...		6 0 0
2 Horse-hoes for fallow-crops (Fig. 41), with moveable mould-boards (shewn in Fig. 42), at L.4, 10s., ...		9 0 0
1 Thrashing-machine of six-horse power (Fig. 45),		100 0 0
This is upon the supposition that horses are employed; but should water or steam be used, there will be an increase in the first cost, although a great economy in the subsequent expense.		
1 Winnowing-machine (Fig. 47), . .		6 10 0
1 Turnip-slicer (Fig. 49); but of which a simpler kind may be used, price . . .		1 10 0
And although not absolutely necessary, there may be,—		
1 Chaff-cutter (Fig. 52), .	L.7 0 0	
1 Steaming-apparatus (Fig. 53),	10 0 0	
And, though less important still,		
1 Corn-bruising machine, .	7 10 0	
	L.24 10 0	
12 Single-horse carts at L.10 (Fig. 54), . .		120 0 0
6 Sparred corn and hay carts, exclusive of axles and wheels, at L.4 (Fig. 55), . . .		24 0 0
1 Water-cart (Fig. 57), . . .		9 0 0
Churn and other utensils of the dairy, . .		10 0 0
This may be the amount when the dairy is the affair of the household; but, where a regular dairy is established, a corresponding set of implements must be obtained.		
2 Wheelbarrows at L.1 (Fig. 59), . .		2 0 0
Carried forward,		L.345 2 0

Brought forward,	L.345	2	0
1 Handbarrow (Fig. 60), . . .	0	5	6
2 Spades at 4s. 6d. (Fig. 61), . . .	0	9	0
6 Broad-pointed lime-shovels at 5s. (Fig. 62), .	1	10	0
4 Narrow-pointed lime-shovels at 4s. 6d. (Fig. 63),	0	18	0
1 Mattock (Fig. 64), ...	0	5	0
1 Pick-axe (Fig. 66), ...	0	5	0
1 Foot-pick (Fig. 65), ...	0	7	0
1 Mall (Fig. 71), ...	0	2	0
1 Hammer (Fig. 70), ...	0	3	0
1 Sledge (Fig. 69), ...	0	4	6
1 Axe (Fig. 68), ...	0	4	6
1 Saw (Fig. 67), ...	0	5	0
6 Three-pronged forks at 4s. 8d. (Fig. 72), .	1	8	0
6 Small three-pronged for spreading dung, at 3s. 6d. (Fig. 73), ...	1	1	0
2 Dung-drags at 3s. (Fig. 80), . . .	0	6	0
2 Mud-scrapers at 3s. 6d. (Fig. 81), . .	0	7	0
6 Long forks at 3s. (Fig. 74), . . .	0	18	0
6 Short forks at 2s. 6d. (Fig. 75), . .	0	15	0
10 Hay-rakes at 1s. 3d. (Fig. 77), . .	0	12	6
10 Turnip-hoes at 1s. 5d. (Fig. 78), . .	0	14	2
2 Turnip-pickers at 2s. (Fig. 209), . .	0	4	0
2 Hedging-bills (Figs. 222 and 223), . .	0	7	0
1 Hedge-spade (Fig. 224), . . .	0	3	0
4 Scythes, 3 long (Fig. 79), and 1 short, with straps and stones, ...	1	9	0
12 Sickles at 1s. (Fig. 138), . . .	0	12	0
1 Hay-knife (Fig. 82), ...	0	4	6
10 Weed-hooks at 6d. (Fig. 136), . . .	0	5	0
2 Straw-twisters at 1s. 6d. (Fig. 146), . .	0	3	0
2 Long ladders of the respective lengths of 24 and 16 feet, ...	2	0	0
4 Short ladders of 8 feet at 6s., . . .	1	4	0
4 Poles for laying off ridges at 1s., . .	0	4	0
20 Binders for cattle at 1s. 6d. (Fig. 202), . .	1	10	0
2 Pairs of sheep-shears at 4s. 6d. (Fig. 211), .	0	9	0
1 Sheep-stool (Fig. 213), ...	0	4	0
2 Sheep-racks at L.1, 2s. (Fig. 210), . .	2	4	0
4 Straw-racks for cattle at 8s. (Fig. 200), . .	1	12	0
1 Flexible tube for cattle (referred to at page 624),	0	7	0
Or 1 Stomach-pump may be substituted L.3, 3s.			
1 Marking-iron for sheep (Fig. 212), . .	0	2	0
Carried forward,	L.369	5	8

		L.	s.	d.
	Brought forward,	L.369	5	8
10	Sheep-nets of 70 yards each at 12s., . .	6	0	0
200	Hardwood stakes for sheep-nets, . .	0	15	0
1	Grindstone (Fig. 84), ...	1	10	0
1	Weighing-machine for wool and grain, with a set of weights, ...	2	0	0
	1 Steel-yard for weighing hay and straw, only necessary on certain farms, . L.10 0 0			
	Tubs for pickling wheat, . . .	0	7	0
	Vessel for holding grease, . . .	0	1	6
	Cart-harness for 12 horses (Fig. 58), . .	41	2	0
	Plough-harness for do. (Fig. 19), . .	12	0	0
	Saddle-horse furniture, ...	6	4	6
1	Corn-chest for work-horse stable, . .	2	10	0
1	Corn-chest for saddle-horse stable, . .	1	0	0
6 1	Currycombs for farm-horse stable, Currycomb for saddle-horse stable, } (Fig. 85), .	0	7	0
7	Brushes at 2s. (Fig. 86), . . .	0	14	0
7	Mane-combs at 6d. (Fig. 87), . . .	0	3	6
7	Foot-pickers at 6d. (Fig. 88), . . .	0	3	6
7	Stable-forks at 3s. (Fig. 76), . . .	1	1	0
6	Pairs of nose-bags at 10s., . . .	3	0	0
2	Stable-lanterns at 5s., ...	0	10	0
2	Hand-lanterns at 2s., ...	0	4	0
1	Pair of horse-scissors (Fig. 89), . .	0	1	6
1	Oil-flask, ...	0	1	6
3	Water-pails at 4s., ...	0	12	0
2	Riddles for wheat at 2s. 6d., . . .	0	5	0
2	Riddles for barley at 2s., . . .	0	4	0
2	Riddles for oats at 2s. (Fig. 153), . .	0	4	0
1	Slap-riddle (Fig. 154), . . .	0	1	8
1	Sieve, ...	0	3	6
2	Close-sieves at 1s. 6d. (Fig. 152), . .	0	3	0
1	Corn-measure (Fig. 155), . . .	0	10	0
2	Wooden-shovels at 2s. (Fig. 156), . .	0	4	0
2	Brooms at 3d., ...	0	0	6
2	Canvass sheets for barn at 10s., . .	1	0	0
100	Sacks to contain 4 bushels each, at 2s., . .	10	0	0
1	Load-barrow (Fig. 157), . . .	0	10	0
4	Canvass-carriers for sheaves at 3s. (Fig. 150), .	0	12	0
	Or the sparred barrows (Fig. 151), 4 at L.1, 5s. each, L.5.			
	Amount of Implements and Machines,	L.463	11	4

2. Live-Stock.

The farm, it has been seen, is to be managed by six pairs of horses regularly employed in ploughing, and in other labours of the farm.

Besides the regular teams, there should be a spare horse, which may be a breeding mare. The uses of a spare horse are, that by it many little operations can be performed,—as carrying water, going to market for articles required for household use or the farm, bringing home green forage and the like,—without breaking in upon the regular labours. It is necessary, too, on such a farm, that the farmer have a saddle-horse, as being indispensable for that economy of time which on every considerable farm must be studied.

The stock of horses may be therefore stated thus:—

13 Work-horses, at L.30, ...	L.390	0	0
1 Saddle-horse, ...	30	0	0
	L.420	0	0

To keep up his stock of horses, the farmer should endeavour to rear one colt every year. Now, the colt being broken in after he has completed his third year, there will be three colts on the farm in addition to the stock mentioned; so that the regular stock of horses upon the farm after a time will be,—

13	Farm-horses.
1	Saddle-horse.
3	Colts.
17	

The next class of live-stock consists of sheep and cattle. To determine the number and kinds of these, we must consider, 1*st*, The quantity of land which can be assigned for keeping them after the horses are supplied; and, 2*d*, The mode of management which it will be expedient to pursue.

The quantity of land in grass, it has been seen, is—

Of young grass, ...	100 acres.
Of grass in its second year, ...	100
	200

The quantity of the young grass required for hay and forage to the horses may be thus computed:

13 Farm-horses, at 20 lb. of hay each per day, for 5 months, ...		348 cwt.
1 Saddle-horse, hay for 9 months, at 20 lb. per day,		48
		396
Add for ewes in winter, colts, and contingencies, .		198
		594
To produce this quantity there will be required, at the rate of 33 cwt. to the acre, ...		18 acres.
To soil the farm-horses, at the rate of $\frac{3}{4}$ acre each, there would be required, . . .	$9\frac{3}{4}$ acres.	
For the saddle-horse, ...	$\frac{1}{4}$	
		10
		28
The young grass in all, is, ...		100
Which leaves to be depastured, of the young grass,		72
And there are, of grass in its second year to be depastured,		100
Making, of grass to be depastured in all,		172

This ground may be depastured partly with sheep, partly with cows, and partly with oxen in the course of being reared and fattened. It is usual, when there is young grass upon a farm, to give it, as being the richest and most succulent, only to the ewes with lambs, and to the stock, whether of sheep or oxen, in the course of being finally fattened. But we may suppose, in the special case of the farm in question, that the whole of the spare young grass, 72 acres, is depastured by sheep; and that the whole of the older grass, 100 acres, is depastured by the

cows and oxen. We have first to consider the number and kinds of sheep which 72 acres of new grass, together with such a supply of turnips as will suffice for the sheep in winter, can maintain.

Now, it is conceived that this quantity of pasture, with a proper supply of turnips, will, upon land of good quality, maintain a regular breeding stock of 120 Leicester ewes, that is, six scores, in the following manner.

The ewes, amounting to 120, may be expected, under a proper system of management and feeding, to produce each year, in the months of March and April, such a number of lambs as that 180 shall arrive at full maturity; and these lambs, for the sake of easier calculation, may be supposed to consist, one-half of males, and one-half of females.

In the month of July, after being weaned, these lambs receive the name of hoggets or hogs. There are, therefore, upon the farm, in each July, of sheep produced in the same year:—

90	Wether-hoggets.
90	Ewe-hoggets.
180	

The ewe and wether hoggets, under the system of management before explained, are to be penned together on turnips during the first winter. They will consume about $13\frac{1}{2}$ acres of turnips, that is $\frac{3}{4}$ of an acre for every ten sheep; and if we allow $1\frac{1}{2}$ acre for the ewes in the season of lambing, there will be 15 acres in all of turnips consumed by the sheep.

Now, the ewe and wether hoggets are penned on turnips till the month of April, when they are turned out to the fields to pasture. In the beginning of June they are shorn, and then they receive the names—the male sheep, of shearling wethers or dinmonts; and the female sheep, of shearling ewes or gimmers. The shearling wethers are now to be sold, and as many of the shearling ewes as it is not necessary to keep upon the farm for breeding.

The regular breeding-stock upon the farm is 120 ewes; and

these ewes may be supposed to be kept on the farm until they have borne each lambs for three successive years. Under this system, one-third of the ewes, that is forty, will be disposed of each year, and their place will be supplied by forty shearling ewes reared upon the farm.

Now, after shearing the sheep in June, there were ninety shearling wethers to be disposed of; and of shearling ewes, there were fifty to be disposed of, the other forty being reserved to receive the ram in October, and supply the place of the forty old ewes.

Under this system of management, then, the ewes add, in each year, to the stock of sheep, 180, and an equal number of sheep are disposed of, namely—

90	Shearling wethers;
50	Shearling ewes;
40	Old ewes.
180	

The sheep-stock on the 15th of May in each year, will therefore stand thus:—

120	Ewes, with their lambs;
90	Wether-hoggets;
90	Ewe-hoggets.
	To which add,
2	Rams.
302	Sheep, with 180 lambs.

These, then, are the kinds and numbers of sheep which the farmer ought to procure when he takes possession of the grass-land of his farm on the 15th of May. But it may be difficult or impossible for an entering tenant to procure at once the precise kinds of stock which he requires. All that he can do, therefore, is to make the nearest approach to it that circumstances will allow, so that he may, as soon as possible, be able to bring his stock into the regular course of management which he proposes to adopt. He may purchase at his entry,—

120	Leicester ewes, with their lambs, at 60s.,	L.360	0	0
40	Ewe-hoggets, which will supply an equal number of the worst of the old ewes in the same year, at 30s.,	60	0	0
2	Shearling rams,	10	0	0
162		L.430	0	0

This, then, may be supposed to be the capital advanced for sheep-stock in the first year.

The next class of stock consists of the cows and oxen. For these there are to be assigned 100 acres of grass for pasture, and such a quantity of turnips as will maintain and fatten them.

It may be assumed that there are ten cows kept upon the farm, and that these ten cows, besides supplying the household dairy, will rear twenty calves.

Now, the manner of management may be that formerly described as applicable to a stock of oxen. The twenty calves, in the first year, after being weaned, are pastured, and fed on turnips and straw; in the second year they are pastured, and in the second winter likewise fed on turnips and straw. They might then be killed fat; but we may suppose, so as to render the management here pointed out practicable upon every farm producing turnips, that they are pastured for a third summer, and put to fatten during the third winter, before the conclusion of which they will have completed their third year, and be, in the language of farmers, three years old. A part of these will be heifers, but it will be unnecessary to embarrass the calculation with this supposition, and therefore we may suppose them to be all males.

Under this system of management, the stock of oxen, on the 15th of May in each year, will be,—

10 Cows.
20 Calves.
20 One-year-old steers, that is, steers that were calved in the preceding year, and have now completed their first year.
20 Two-year-old steers, that is, cattle that have completed their second year, and are to be fed on turnips in the following winter.
And there may have been 20 three-year-old oxen, fattened on turnips, but which may be supposed to have been disposed of before the 15th day of May.
1 Bull.
———
71

The number of cattle, then, belonging to the farmer, to be pastured upon the farm, is,—

10 Cows.
20 Calves.
20 One-year-old steers.
20 Two-year-old steers.
1 Bull.
———
71

And this, therefore, is the stock to be purchased on the 15th of May in the year of entry. It may not, perhaps, be practicable to get the precise kinds of stock required in the first year, but a near approach to it may generally be made. It may, therefore, be supposed that the capital advanced in the first year for this class of stock is, for—

10 Cows calved, and which have again received the male, at L.12,	L.120	0	0
20 Calves, at 30s.,	30	0	0
20 One-year-old steers, at L.7, 10s.,	150	0	0
20 Two-year-old steers, at L.12, 10s.,	250	0	0
1 Bull, one-year-old,	15	0	0
71	L.565	0	0

The quantity of grass-land to be depastured is 100 acres, which will suffice, if the land be of medium quality, to pasture the

quantity of cows and oxen mentioned. But they will also require the following quantities of turnips :—

20 Calves will require $\frac{1}{4}$ acre each, . . .	5 acres.
20 One-year-old steers, $\frac{3}{4}$ acre each, . .	15
20 Two-year-old steers, put to fatten, 1 acre each, .	20
10 Cows, about $\frac{1}{4}$ acre each, ...	$2\frac{1}{2}$
1 Bull, ...	$\frac{1}{2}$
Spare produce for incidents, . . .	2
71	45

If to this be added the 15 acres required by the sheep-stock, it will be seen that the division of the farm which is to be in turnips every year will suffice for keeping the stock.

The next class of live-stock is attended with no difficulty, namely, the swine. These will soon breed up to the quantity required. At the entry in May, there may be purchased—

2 Breeding sows, at L.2, ...	L.4	0	0
1 Young boar, ...	1	0	0
	L.5	0	0

The remaining class of live-stock consists of poultry. This, like the last, will quickly breed up to the numbers wished for. In the first year may be purchased,—

20 Chickens, ...	L.1	10	0
12 Ducks, ...	0	18	0
3 Geese, ...	0	12	0
3 Turkeys, ...	0	15	0
	L.3	15	0

The capital, therefore, advanced for the different classes of live-stock will be as under :—

1. Horses, ...	L.420	0	0
2. Sheep, ...	430	0	0
3. Cattle, ...	565	0	0
4. Swine, ...	5	0	0
5. Poultry, ...	3	15	0
	L.1423	15	0

3. Seeds.

Previous to the period when the farmer takes possession in May, there ought to have been sown the grass and clover seeds on the division of the farm which, in the regular course, is to be sown with them. The outgoing tenant, however, has no interest in sowing these seeds, of which he does not reap the benefit; but the entering tenant either sows them, or pays the cost of them to his predecessor. Now, supposing the same rotation to have been hitherto adopted as is now to be adopted, there will be a division of 100 acres to be sown with grass-seeds, namely, that which is in wheat and barley.

100 Acres sown with perennial ryegrass seeds, at 1 bushel per acre, at 3s. per bushel,	L.15	0	0			
Clover seeds, 10 lb. per acre, at 10d. per lb., . . .	41	13	4			
				L.56	13	4
And in the second spring there will be an equal quantity to be sown, ...				56	13	4

Tares to be sown in the first year for horses and pigs :—

5 Acres, at 3 bushels per acre, = 15 bushels, at 5s. per bushel, ...	3	15	0

Arrangements, too, should be made in the first year to plant potatoes—

5 Acres, at 24 bushels per acre, = 120 bushels, at 1s. 4d. per bushel, ...	8	0	0

The further seeds to be sown in the year of entry are—

60 Acres of turnips, at 2 lb. per acre, = 120 lb., at 9d. per lb., ...	L.4	10	0			
The same quantity in the following year,	4	10	0			
				9	0	0
Carried forward,				L.134	1	8

Brought forward,	L.134	1	8

There is no corn to be sown in the spring of the year of entry; but in the autumn of the same year the division of the land in summer-fallow and potatoes, namely, 40 acres, is to be sown:—

40 Acres of wheat, at 3 bushels per acre, = 120 bushels, at 6s. 8d. per bushel, . . .	40	0	0

In the spring of the second year are to be sown the oats, tares, and barley, namely,—

95 Acres of oats, at 5 bushels per acre, = 475 bushels, at 2s. 8d. per bushel, . . .	63	6	8
5 Acres of tares, at 3 bushels per acre, = 15 bushels, at 5s. per bushel, ...	3	15	0
60 Acres of barley, at 3 bushels per acre, = 180 bushels, at 3s. 8d. per bushel, . .	33	0	0
	L.274	3	4

4. Manures.

The dung made in the preceding winter has not at the period of entry been applied to the land, because the land to be in turnips and summer-fallow, to which, in the regular course, it would be applied, is not yet ready to receive it. This dung may either be received by the entering tenant, according to the practice of certain districts, free of charge, or he may pay to his predecessor the price or value of it. Making this latter assumption,—

The quantity of dung may be supposed to be 1000 tons, which, at 6s. 3d. per ton, . .	L.312	10	0

A tenant does not always lime his land in the first year of his possession, and yet it is often very important that he should do so. Let it be supposed

Carried forward,	L.312	10	0

Brought forward,		L.312 10 0

that he limes 40 acres in the summer of the first year, and an equal quantity in the summer of the second year.

80 Acres, at 144 bushels per acre, = 11,520 bushels, at 3d. per bushel, prime cost,	L.144 0 0	
Tolls and other charges, the distance being supposed 12 miles, at the rate of $1\frac{1}{4}$d. per bushel, .	60 0 0	
		204 0 0
		L.516 10 0

5. Labour.

6 Ploughmen, at 1s. 9d. per day, 313 days, or L.27 : 7 : 9 per annum, for $1\frac{1}{2}$ year, .	L.246 9 9
1 Principal servant or overseer, at 2s. per day, or L.31, 6s. per annum, for $1\frac{1}{2}$ year, . .	46 19 0
1 Shepherd, wages the same as the overseer, .	46 19 0
1 Hedger, employed chiefly in hedge-work, but also in other work upon the farm, 1s. 9d. per day, for $1\frac{1}{2}$ year, ...	41 1 $7\frac{1}{2}$
1 Extra labourer, to take charge of the cattle in winter, and do any common work in summer, at 1s. 6d. per day, for 1 year, . . .	23 9 6
Females and young persons are employed in hoeing turnips, and other work. Their wages for $1\frac{1}{2}$ year may be, ...	60 0 0

The entering tenant takes possession of the land to be worked for fallow and fallow-crops in May. But, previous to this time, it ought to have received, at least, one ploughing, for which the entering tenant pays those who have laboured it :—

100 Acres fallow, at 7s. per acre, . .	35 0 0
Carried forward,	L.499 18 $10\frac{1}{2}$

Brought forward,		L.499	18	10½

The other items of outlay on labour are :—

Mowing hay, 18 acres at 2s. 6d. per acre,	L.2	5	0			
The same the second year, . .	2	5	0			
				4	10	0
Expense of the harvest work in the second year, that is, for the first crop raised by the new tenant, 195 acres at 9s. 4¾d. per acre, . . .				91	12	2¼
Keeping up the iron-work of horses and implements, at the rate of L.3 per pair of horses, 1½ year,—L.27. But the implements being new, the half of this will suffice for the first 18 months, . .				13	10	0
Carpenter work, on the same principle, . .				13	10	0
Additional blacksmith and carpenter work, .				5	0	0
Saddler's work, at the rate of L.1 per pair of horses, for 1½ year, ...				9	0	0
Shoeing saddle-horse for 1½ year, . .				1	10	0
Keeping houses in repair for 1½ year, L.7, 10s., but the houses being new, or put into a sufficient state of repair, one-half may suffice for the first 18 months, ...				3	15	0
Incidental expenses, drugs to live-stock, oil for lamps, candles, tolls, expenses of marketing, &c., .				16	0	0
				L.658	6	0¾

6. Maintenance of Horses.

The annual expense of a working-horse, according to the method of keeping horses formerly described, may be calculated thus :—

Oats, 91¼ bushels, at 2s. 8d. per bushel, . .	L.12	3	4
Green forage, ¾ of an acre, at L.7, 10s., . .	5	12	6
Hay for five months, at 20 lb. per day, = 26 cwt. 3 qr. 4 lb., at 3s. 6d. per cwt., . . .	4	13	9
Tares, ¼ acre, at L.7, 10s., ...	1	17	6
	L.24	7	1

The outlay on feeding horses, for the first 18 months, may be calculated as under :—

Hay for three weeks after entry for thirteen horses, at 20 lb. per day, = $48\frac{3}{4}$ cwt. at 3s. 6d. per cwt.,	L.8	10	$7\frac{1}{2}$
Hay for saddle-horse after entry, 4 cwt. at 3s. 6d.,	0	14	0
Oats for thirteen horses for the first year, at $91\frac{1}{4}$ bushels each = $1186\frac{1}{4}$ bushels at 2s. 8d., . .	158	3	4
Oats for $4\frac{1}{2}$ months in the second year, until the crop can be made available, = $438\frac{3}{4}$ bushels, at 2s. 8d. per bushel, ...	58	10	0
Oats for saddle-horse for 1 year and $4\frac{1}{2}$ months, = 125 bushels, at 2s. 8d., ...	16	13	4
	L.242	11	$3\frac{1}{2}$

7. Burdens.

Poor-rates, highway conversion-money, assessed taxes, insurance, &c. vary greatly in different localities. Let them be assumed on a medium to be L.50 per annum, or for $1\frac{1}{2}$ year, . .	L.75	0	0

ABSTRACT.

The various items of capital enumerated are as follows :—

1. Implements and Machines, . . .	L.463	11	4
2. Live-stock, ...	1423	15	0
3. Seeds, ...	274	3	4
4. Manures, ...	516	10	0
5. Labour, &c., ...	658	6	$0\frac{3}{4}$
6. Maintenance of horses, . . .	242	11	$3\frac{1}{2}$
7. Burdens, ...	75	0	0
	L.3653	17	$0\frac{1}{4}$

To this sum should be added :—

1. Proportion of the rent which may be supposed to be paid before the first corn-crop is reaped, ...				L.460	16	$1\frac{1}{2}$
2. Expense of furnishing a dwelling-house, . .	L.200	0	0			
Family expenses for $1\frac{1}{2}$ year,	150	0	0			
				350	0	0
Amount of outlay,				L.4464	13	$1\frac{3}{4}$

PRODUCE SOLD.

Those parts of the produce of the farm sold during the first 18 months, and which must be taken into account, are :—

20 Two-year old cattle, which, after being wintered on turnips, and when they have passed their third year, may be reasonably supposed to weigh 65 stones, at 6s. per stone, . . .			L.390 0 0
40 old ewes, at 40s., . .		L.80 0 0	
The same for the second year, .		80 0 0	
			160 0 0
50 Shearling ewes, } 90 Shearling wethers, } at 40s., . .			280 0 0
50 Pigs, which may be reared each year to 7 stones each, at 3s. 6d. per stone, .		L.61 5 0	
One half-year more, . . .		30 12 6	
		L.91 17 6	
But during the first eighteen months the calculation may be one-half, . .			45 18 9
Produce of dairy, which, besides rearing calves, may be supposed to be at the rate of 50s. per cow per annum—$1\frac{1}{2}$ year, ...			37 10 0
There will be 162 fleeces of wool sold the first season, viz.—			
120 Ewes, at $6\frac{1}{2}$ lb. each, .		780 lb.	
40 Ewe-hogs, at $7\frac{1}{2}$ lb. each, .		300	
2 Young rams, at 8 lb. each,		16	
		1096 lb.	
There will be 302 fleeces the second year, viz.			
120 Ewes, at $6\frac{1}{2}$ lb. each,	780 lb.		
180 Ewe and wether hogs, at $7\frac{1}{2}$ lb., . .	1350		
2 Rams, at 9 lb., .	18		
		2148	
		3244 lb.	
3244 lb. of wool, at 1s. per lb., . . .			162 4 0
Amount of produce sold,			L.1075 12 9

Amount of outlay during the first eighteen months,	L.4464	13	$1\frac{3}{4}$
Produce sold,	1075	12	9
Net capital,	L.3389	0	$4\frac{3}{4}$

Being at the rate of L.6 : 15 : $6\frac{3}{4}$ per acre imperial, or, exclusive of the rent, L.5 : 17 : $1\frac{1}{2}$.

IV. EXPENSES AND PRODUCE OF THE FARM.

The capital necessary for a farm is the fund which ought to be available to the possessor, that he may carry on his business: the annual expenses of a farm are the necessary charges to which a farm is subject. A very convenient period for determining the annual expenses of a farm is from May to May, but it may be done also from November to November, or indeed from any one period in the year to the same period in the following one, so as to comprehend the charges of the entire year.

To calculate the average charges of a farm, the same data are assumed as in calculating the capital, namely, that the farm consists of 500 acres, and that it is managed, with respect to rotation of crops and the number and disposition of live-stock, in the manner already explained.

The first consideration, and a large charge in the calculation of farm expenses, is Rent. Ingenious reasonings have been employed to shew, that rent is necessary to equalize the profits of land of different degrees of fertility; that, in every country, it is a charge as necessary as the wages of labour: but here we have only to consider the fact, that rent is a charge upon all who farm the lands of others in this country.

The amount of rent should be such as to leave to the occupier a sufficient interest upon the capital advanced by him. This will in some degree depend upon the general rate of interest in the country, so that, *cæteris paribus*, rent should rise as the rate of

interest falls. Thus, supposing that, when money is at 4 per cent., the farmer required 15 per cent. on his capital, when the general rate of interest has fallen to 3 per cent., he should receive $11\frac{1}{4}$ per cent. The advances of the farmer have been calculated at L.3389 : 0 : $4\frac{3}{4}$, but from this there are to be deducted L.460 : 16 : $1\frac{1}{2}$, being the half-year's rent supposed to be paid before the first crop is reaped, together with L.350 for family expenses and the furnishing of a dwelling-house, leaving, as the capital upon which interest should be charged, L.2578 : 4 : $3\frac{1}{4}$, upon which sum 15 per cent. is L.386 : 14 : $7\frac{3}{4}$. Taking this as the farmer's return, and assuming certain rates of farm-produce after mentioned, the rent of the farm to which these calculations refer will be L.921 : 12 : 3.

(1.) *EXPENSES.*

The various kinds of outlay in money on a farm may generally be classed under five heads :—1. Rent and burdens ; 2. Stock purchased ; 3. Seeds purchased ; 4. Manures ; 5. Labour and minor outlays.

The amount of these is the outlay in money. The wages of the labourers indeed may be paid in produce, or partly in produce and partly in money ; but it is better, in calculating the outlays upon a farm, to consider the wages of the labourers as a payment in money. What is consumed upon the farm, the produce of the farm itself, as seeds, corn and hay for horses, turnips, and the like, ought not to be regarded as an outlay, but as a diminution of the produce of the farm. When the outlay in money is known, the farmer has merely to deduct this from the produce of the farm which he can bring to market, to ascertain his profit. The following calculations, then, shew the annual expenses of the farm, including the wages of the labourers, in money ; and it is to be kept in mind, that these calculations are, as in the case of those regarding capital, nothing more than an example, and that they have an especial reference to local usages,

and to a condition of the farmer which applies only to a given district.

1. Rent and Burdens.

	L.	s.	d.
Rent,	L.921	12	3
Burdens,	50	0	0
	L.971	12	3

2. Stock Purchased.

	L.	s.	d.
10 Calves, at 30s.,	L.15	0	0

3. Seeds Purchased.

	L.	s.	d.
60 Acres turnips at 2 lb. per acre, = 120 lb., at 9d.,	L.4	10	0
5 Acres tares, at 3 bushels per acre, = 15 bushels, at 5s.,	3	15	0
100 Acres ryegrass seeds, at 1 bushel per acre, = 100 bushels, at 3s.,	15	0	0
100 Acres clover-seeds, at 10 lb. per acre, = 1000 lb., at 10d.,	41	13	4
	L.64	18	4

4. Manures.

	L.	s.	d.
It may be assumed that the whole land is limed once during the first 10 years of the lease, at the rate of 50 acres annually: 500 acres, at 144 bushels per acre = 72,000 bushels, at $4\frac{1}{4}$d. per bushel, = L.1275. This for 20 years, supposing 20 years to be the duration of the lease, will be, per annum,	L.63	15	0
And further, there may be supposed to be laid out annually, for foreign manures, as bone-dust, rape-dust, &c.,	25	0	0
	L.88	15	0

5. Labour, &c.

6 Ploughmen, at 1s. 9d. per day, 313 days, .	L.164	6	6
1 Overseer, at 2s. per day, . . .	31	6	0
1 Shepherd, at 2s. per day, . . .	31	6	0
1 Hedger, at 1s. 9d. per day, . . .	27	7	9
1 Person to take care of cattle, &c., at 1s. 6d. per day,	23	9	6
Hoeing, haymaking, &c., . . .	40	0	0
Mowing hay, 18 acres at 2s. 6d. per acre, .	2	5	0
Harvest work, 195 acres at 9s. 4¾d. per acre, .	91	12	2¼
Carpenter's work for implements, at the rate of L.3 per pair of horses, ...	18	0	0
Iron-work for implements, at the same rate, .	18	0	0
Saddler's work, at the rate of L.1 per pair of horses,	6	0	0
Shoeing saddle-horse, ...	1	0	0
Additional iron and carpenter work, not included in the above, ...	7	0	0
Keeping houses in repair, . . .	5	0	0
Expenses of carrying grain to market, supposing the distance to be 12 miles, carrying fuel, marketing, and delivery of stock, farriery, and minor charges,	32	16	6
	L.499	9	5¼

ABSTRACT.

1. Rent and burdens, ...	L.971	12	3
2. Stock purchased, ...	15	0	0
3. Seeds purchased, ...	64	18	4
4. Manures, ...	88	15	0
5. Labour, &c., ...	499	9	5¼
	L.1639	15	0¼

(2.) *PRODUCE.*

There remains to be considered what, on this calculation of expenses, may be the annual return of such a farm. This may be comprehended under two divisions—Vegetable Produce, and Live-Stock.

1. Vegetable Produce.

			Bushels.
95 Acres of oats, at 48 bushels per acre, . .			4560
The quantity consumed upon the farm is—			
For seed, . . .	475	bush.	
For work-horses, . .	1186¼		
For saddle-horse, . .	91¼		
For colts, hogs, and poultry, .	60		
			1812½
Leaving for sale,			2747½

2747½ Bushels, at 2s. 8d., . .		L.366	6	8
40 Acres of wheat, at 24 bushels per acre,	960 bush.			
Deduct for seed, 3 bushels per acre,	120			
840 Bushels, at 6s. 8d., . . .		280	0	0
60 Acres of barley, at 42 bushels per acre,	2520 bush.			
Deduct for seed, 3 bushels per acre,	180			
2340 Bushels, at 3s. 8d., . .		429	0	0
Net annual return of Vegetable Produce,		L.1075	6	8

2. Live-Stock.

The sale of horses upon some farms is a source of profit; on a regular farm, however, it will be safer not to calculate upon the profit derived from the breeding of horses, but rather to suppose that the horses reared are just sufficient to repair the casualties, and replace the tear and wear of the original stock.

The produce of the dairy, after rearing 20 calves, may be calculated at 50s. per cow, or	L.25	0	0
50 Pigs may be supposed to be sold or used each year, fed to 7 stones, at 3s. 6d. per stone, . .	61	5	0
Poultry, ...	7	10	0
20 Steers, after being wintered on turnips, supposed to weigh 65 stones each, at 6s. per stone, .	390	0	0
40 Old Ewes, at 40s., ...	80	0	0
Carried forward,	L.563	15	0

Brought forward,	L.563	15	0
50 Gimmers, 90 Dinmonts, at 40s.,	280	0	0
Wool, 2148 lb. at 1s.,	107	8	0
Net annual return of Live-stock,	L.951	3	0

ABSTRACT.

Vegetable produce,	L.1075	6	8
Live-stock,	951	3	0
	L.2026	9	8

If, from the gross produce as above,	L.2026	9	8
Be deducted the expenditure in money,	1639	15	0¼
The net return to the farmer will be,	L.386	14	7¾

Out of which sum he must maintain himself, and bear the hazard of bad debts, unforeseen losses, and the general casualties of trade. Should the produce be assumed to be less, or the capital or expenses greater, the amount of rent will be in a corresponding degree diminished; and *vice versa*, should the amount and rates of produce be greater, or the capital and expenses less.

5. OPERATIONS OF THE FARM IN THE ORDER OF TIME.

The operations of the farm, connected with tillage and the management of live-stock, have been described; but we have yet to consider these operations in the order of time in which they succeed to one another. This review will tend to render more precise a previous knowledge of details, and to lessen that perplexity which is often experienced by those who are brought to the study of practice for the first time, and see so many different labours carried on together, and without apparent order. It will here suffice to detail the most important of these labours, as they

occur in a well-ordered farm, employed partly in tillage, and partly in the rearing and feeding of live-stock, and managed according to the system of agriculture which has been especially described in this work. But in speaking of farm-labours proper to peculiar months and periods, it is to be observed that great allowances must be made for the state of the weather, the forwardness or backwardness of the season, and the climate of the farm.

November.

The month of November may be said to be the commencement of the farmer's year. By this time the labours of his harvest have been completed, and his produce has been secured; and he is now proceeding to prepare the ground for the crop of another season. There are to be considered the state of the farm at the commencement of this month with respect to labour and live-stock, and the principal operations during its continuance.

Live-stock.—The cattle may be supposed to consist of cows; of a certain number of calves; of a certain number of the steers and heifers of the preceding year, termed therefore one-year-olds, as having completed their first year, but now approaching to the end of their second year; of a certain number of steers and heifers which have completed their second year, and are therefore termed two-year-olds, though now approaching the end of their third year: and of a bull. The two-year-old steers and heifers are now arrived at maturity; the heifers intended for breeding have received the male in the course of the season, and the older steers are ready for final fattening,

As the month of October had advanced the pastures had begun to fail, and by the termination of the month the various cattle had been put in their respective houses, yards, and stalls.

The cows which had borne calves in the early part of the year, had been put in the cow-house and tied in their respective stalls,—straw, and a limited proportion of succulent food, as turnips, having been supplied to them.

The calves which were born in the early part of the year, had been put in one or more yards with sheds, had been well littered, and had received straw as their provender, with an allowance of turnips.

The steers and heifers of the preceding year, now turned their first year, and approaching the end of their second year, had also been put into yards with sheds. They had likewise been plentifully littered, receiving straw as provender, with an allowance of turnips.

The older cattle, namely, those that have completed their second year, had been treated thus :—Such of them as were heifers to be retained for breeding, had been separated from the males in the preceding spring, had received the male as they came into season in spring and the early part of summer, and, being with calf, had been put into yards with sheds, to be tied to their respective stalls, when within a few weeks of calving. The steers, again, which are now to be finally fattened, had either been tied in stalls, or put into yards with sheds, in either case receiving a full allowance of turnips or other nourishing food.

The bull had been put into a shed or yard by himself, receiving straw for provender, and a sufficient supply of turnips.

Such may be supposed to be the arrangement of the cattle at the commencement of the month of November. The same treatment with respect to them is to be continued during the entire month :—The cows and heifers are to receive straw, with a modified allowance of turnips : the calves and steers straw, with a full allowance of turnips.

The sheep, again, consisting, it may be assumed, of a regular breeding stock of ewes, may be supposed to have been arranged and treated thus :—The ewes, consisting partly of sheep that had borne lambs, had, by the 10th of October, the rams admitted to them. At the beginning of November, the rams and ewes are still pasturing together, receiving no other food but grass ; and by the middle of the month the rams are withdrawn.

The lambs born in spring, now termed ewe and wether hoggets, had, on the failure of the pastures in October, been penned on

turnips. At the beginning of November they continued penned on turnips, the province of the shepherd being to attend to them as well as to the other sheep, and to shift the pens when necessary.

The horses, in the month of October, had been put upon their full allowance of hay and corn. At the beginning of November they are receiving full feeding, but before the middle of the month, when the hours of labour become short, the hay may be withdrawn, straw substituted, and the allowance of oats reduced to the half of the former quantity.

By the beginning of the month the colts had been put into their yards, or into a paddock with a shed, receiving straw or hay as provender, with any succulent roots, as turnips and potatoes.

The swine and poultry are receiving their usual food. The pigs are fattened at all times; and the poultry receive their regular supplies of food in their yard: and as the same method of management continues throughout the year, the feeding of this class of stock need not be again adverted to.

Labour.—As soon as the season of harvest was over, and the crop secured, the operation had been begun of ploughing the stubble-land—that is, the land which, having borne a crop of corn, is intended to be in summer-fallow, or fallow-crops, as turnips and potatoes, in the following year. At the beginning of November, then, the stubble-land is being ploughed, and this operation is continued throughout the month, the horses being kept regularly employed at this work, unless interrupted by frost or snow, or otherwise necessarily engaged.

The thrashing of the crop is now carried on, so as to supply straw for litter and provender in a regular manner to the cattle. The corn is prepared and carried to market, that being retained which is required for feeding the stock upon the farm.

At the commencement of and during the month, turnips are carried home in carts to the stock in the houses and yards, every two or three alternate drills being taken up for the cattle, while

the remainder is left in the ground for the sheep which may be penned in the field.

This is the fitting season for pruning hedges, cleaning ditches, and performing other operations upon the live-fence. Hedger and ditcher work are, therefore, carried on during all the month of November, and draining and any kind of work by the spade. The work of the hedger is continued for the greater part of winter when the weather allows, in spring, in the early part of summer and autumn; and draining and other spade-work are carried on at every convenient season. These labours of the farm, therefore, need not be afterwards referred to.

Winter being now at hand, it will be prudent to secure a supply of fuel, which the horses may be employed to bring home when they are not otherwise occupied.

These, then, have been the principal labours of the farm during the month of November, which may be said to be the first month of the winter quarter:—The cattle and sheep of all kinds have been receiving their winter food; the horses, from a full allowance of hay and corn, have been put upon straw and a smaller allowance of corn; the operation of thrashing has been carried on; the horses have been chiefly employed in ploughing the stubble-land for the fallow-crops and summer-fallow of the next year; the hedger has been engaged in repairing the hedges, and spade-work when required has been going on; and a supply of fuel has been provided against approaching winter.

December.

Live-stock.—The cows are in the cow-houses; the young cattle in their yards; the feeding cattle in their houses or yards as before; and they are all kept and treated in the same manner throughout the month.

The ewes are, as before, on grass, but in snows or hard frosts they receive an allowance of hay. The ewe and wether hoggets are penned on turnips as before, and are kept so during the month.

The hours of daylight, and consequently of labour, being short, the horses are still fed on straw, and receive their modified allowance of corn. The colts are in their yard or paddock receiving straw or hay, with an allowance of green food, and are kept so during the month.

Labour.—The ploughing of the stubble-land continues during this month when the weather allows; and, in ordinary circumstances, it may be calculated that all the land intended for fallow and fallow-crops has been ploughed before the termination of the month.

Thrashing is continued throughout the month so as to supply the stock regularly with straw, and the grain is carried to market in proportion as it is got ready. The wheat and barley straw is used chiefly for litter, and the grain is sold. The oat-straw is used for fodder, but instead of all the oats being sold, a portion of them may now be stored in the granary for the purpose of being used for seed in spring.

A quantity of turnips should be pulled to be ready for the cattle in case of frost and snow. A portion should be placed either in a store in the open air, or, which is better, under a shed. Those given to the older fattening stock should be cut by the turnip-slicer.

Towards the end of the month, should the weather not admit of ploughing, the carts are to be employed in carrying out dung from the yards, to be piled in heaps in the fields in which the turnips and other fallow-crops are to be grown in the following year.

During the month of December, then, the stock of all kinds have been put on their winter food; the horses have been on short day's work, and on their winter allowance of corn and straw; they have been employed in ploughing the remainder of the stubble-land, in bringing home turnips to the stock, in carrying corn to market, and towards the end of the month in taking out dung from the farm-yards.

December may be said to be the dead season of the farmer's

labour, and yet it is not without its objects of interest and solicitude. The farmer is engaged in realizing his profits; his animals of different kinds are feeding under his care; and he is soon to look to the more active labours of spring.

January.

Live-stock.—The cattle are still in their houses and yards, and are fed as during the last month; turnips being brought home, and a store kept in reserve as formerly. Some of the cows may calve during this month, especially towards the end of it. They are to be well attended to at this time; and the calves separated from them at the birth, and fed on new milk three times in the day.

The ewes are on grass-land, receiving hay when the weather renders it necessary. The ewe and wether hoggets continue penned on turnips as during the previous month.

The horses are on straw, and are receiving their short allowance of corn. The colts are in their yard or paddock, and are fed as before.

Labour.—The stubble-land intended for fallow and fallow-crops may be supposed to have been ploughed by the end of the last month. The land in grass intended to be sown with oats in spring, may now, therefore, be begun to be ploughed, and the horses kept engaged in this operation when the weather allows, and when they are not otherwise necessarily engaged.

Corn is to be thrashed to furnish straw for provender and litter, as during the preceding month. Wheat and barley are to be sent to market as usual, and the storing of oats for seed may be continued.

Turnips are brought home to the cattle in the houses and yards as formerly; and dung, when the weather will not admit of ploughing, is carried out from the yards.

These, then, have been the principal operations in the month of January :—The cattle have been fed on straw and turnips as in the former month ; the ewes have been kept on grass, receiving hay during hard frost and snow ; the ewe and wether hoggets have been penned on turnips as before ; the horses have been kept on straw and their short allowance of corn ; the thrashing of the corn has been proceeding ; the grass-land intended for oats has been ploughed as the weather has allowed ; and the dung has been carried out from the yards.

February.

Live-stock.—The cattle are in their houses and yards, and are fed as during the last month. The cows will calve during this month, and must be carefully attended to.

The ewes are on grass ; but after the middle of the month they should have turnips carried to them in the fields in which they are pasturing, so as to prepare them for the lambing season by the middle of next month. The ewe and wether hogs are penned on turnips as before.

By the middle of the month, if not sooner, the horses should be put again upon hay, and receive their full allowance of corn, in preparation for their work in spring.

Labour.—The ploughing of grass-land intended for oats proceeds during the month, and it is usual that the land which is to be first sown shall be first in the order of being ploughed.

Corn as before is thrashed, so as to afford straw regularly for provender and litter. The corn which is still for sale is carried to market ; the oats which it is yet necessary to reserve for seed are stored. Barley, too, may now be stored, in preparation for the sowing of barley in April.

The land from which turnips have been cleared is now to be formed into ridges ; and in frosty weather, when the ploughs can-

not work, the dung is to be carried from the yards to the fields as formerly.

If spring-wheat is to be sown upon the land that has been in turnips, it may be done when the land is dry and the weather favourable; and should there be beans to be sown, the land may be worked, and the beans sown when the ground is dry.

The following, then, have been the principal operations in the month of February:—The cattle have been kept in their houses and yards, feeding as formerly; the cows have been attended to when calving; the young sheep have been on turnips, and the ewes have received turnips after the middle of the month; the horses have been put on their full work, and have received their full allowance of food; corn has been thrashed in proportion as the stock has required straw for provender and litter; the grain has been sold or stored for seed; the land in grass has been ploughed for oats; the cleared turnip-land has been formed into ridges, and where spring-wheat was to be sown, that has been done; if the weather has allowed, the land intended for beans has been worked, and the beans have been sown; and in frosty weather dung has been carried out from the yards.

March.

Live-stock.—The cattle are still in their yards, and feeding as before. During the month all the cows may be supposed to have calved. The additional calves required are to be purchased, the best and earliest that can be obtained.

The ewe and wether hoggets are on turnips as before. The ewes will now begin to lamb. They have been hitherto receiving turnips, but as they lamb they are transferred with their young to new grass. The male lambs are castrated in lots when about eight days old.

The horses are on full work, and are receiving their full allowance of hay and corn. The colts are receiving hay.

Labour.—The corn is thrashed throughout the month to supply straw. The grain is sold, except such of the oats or barley as are required for seed, or the purposes of the farm.

If any of the grass-land intended for oats has not yet been ploughed, it must now be done; and any turnip-land cleared of turnips, and not yet ploughed, must now be ploughed.

The oats are now to be sown as soon in the month as the land is sufficiently dry: the late ripening sorts being the first in the order of sowing, and next the more early.

Tares are to be sown in portions, at intervals of ten days or a fortnight, so that they may be ready in succession in summer and autumn. The land intended for potatoes may now be cross-ploughed. Towards the end of the month, if the weather and state of the ground allow, the grass and clover seeds may be sown amongst the growing wheat. The land is to be harrowed, and it may at the same time be rolled: but the rolling may be delayed until the month of April. The dung intended for the early-sown turnips should now be turned over, to hasten the putrefactive process.

These, then, have been the principal operations of the month of March:—The cattle have been fed on straw and turnips as before; the calves have been fed on new milk; the young sheep have been fed on turnips; the ewes, after lambing, have been transferred with their young to new grass; the horses have been fully worked and fed; the corn has been thrashed, and barley stored for seed; any remainder of the grass-land not yet ploughed has been ploughed, and also any land cleared of turnips; oats have been sown, and tares in portions at intervals; grass and clover seeds, if the weather has been favourable, have been sown amongst the growing wheat; and the dung for early turnips has been turned.

April.

Live-stock.—The cattle are still in their yards, and are fed as before; the calves are receiving milk, with such nourishing substances in addition as may enable the milk of each cow to bring up two calves.

The ewes are now on new grass with their lambs. At the commencement of the month, the ewe and wether hoggets are still on turnips, but by the middle of the month they are removed from turnips, and put on grass.

The horses are on full work, and receive a full allowance of hay and corn. The colts that have reached their third year may now be taken up and trained to work; or they may be allowed another summer's grass, and be taken up for training in autumn. Mares will foal during this month.

Labour.—If any part of the oats had not been sown during the preceding month, they are now to be sown; if the grass and clover seeds had not been sown amongst the growing wheat, they are now to be sown.

The potato-land which had been cross-ploughed in the preceeding month, is to be ploughed again, harrowed, and otherwise worked, and the potatoes are to be planted.

The land which had been for some time cleared of turnips and ploughed, receives a second ploughing or seed-furrow; that which is just cleared may receive only one ploughing. The barley is sown, the grass and clover seeds are sown and harrowed, and the land is rolled. If the wheat-land had not been rolled at the time of sowing the grass-seeds, it may now be rolled.

The land in new grass, and intended to be mown, is to have the stones upon the surface gathered, and to be rolled.

The barley being sown, and that as early in the month as possible, the preparation of the land for turnips commences; but it is proper that the land intended for summer-fallow should also at this time receive one ploughing, so as to keep down the growth

of weeds, and facilitate the subsequent preparation of the ground; therefore the whole land intended for summer-fallow and turnips is now to be ploughed,—the land intended for turnips in the first place, and across,—the land intended for summer-fallow lengthwise, so as to preserve the former ridges.

In preparing the land for turnips, that intended for the early-sown kinds is to be first worked, and care must be taken that the dung to be applied be in a proper state of preparation. If the dung is not so, the heap must be turned a second time; and the heaps intended for the later-sown turnips must also be turned.

The cattle being in their yards during the whole of this month, the thrashing of corn, so as to yield straw for provender and litter, has been proceeding as hitherto.

These, then, have been the principal operations in the month of April:—The cattle have been fed in their yards with straw and turnips; the calves have been receiving milk; the ewes and lambs have been fed on new grass, and the ewe and wether hoggets, after having been fed on turnips till about the middle of the month, have been put also on grass; oats have been sown, if they have not already been sown; the potato-land has been planted; the land cleared of turnips has been ploughed, and the barley and the grass and clover seeds have been sown; all the land which it is necessary to roll has been rolled, namely, the barley-land, the new grass-land intended for mowing, and the wheat-land which had not been previously rolled; the land intended for turnips and summer-fallow has been ploughed, and the heaps of dung for turnips have been turned; and corn has been thrashed in the quantity necessary to furnish straw for the live-stock.

May.

Live-stock.—At the commencement of the month, the cattle are in their yards and are fed as before.

By the middle of the month, the former year's calves, now

yearling steers, and the two-year-old steers, if the grass is sufficiently advanced, are turned out to pasture; the cows are turned out to pasture; and here it may be observed, that if there are any of the two-year-old cattle which are heifers from which it is wished to breed, they must be separated from the steers of the same age, and placed amongst the cows, and when they come into season, if they have not already done so, they must receive the male. During this month the older cows should all have received the male, so that they may calve in the following February.

With respect to the fattening oxen now turned their third year, and consequently three-year-olds, these may be fed during the month as long as there are turnips sufficient for them, and then sold.

During this month the mares should all have received the male, so that they may foal in the subsequent month of April. The colts are turned out for the season to grass.

As the weather becomes warm, the sucking calves may be turned out to a small paddock. After being weaned in their fourth month, they are turned out to feed for the remainder of the season, along with the cows and other stock.

The sheep of all kinds at the commencement of the month were on grass, and they continue to be pastured in their respective fields during the month. By the end of it, the fat sheep, if ready, may be washed and shorn, or else these operations are deferred till the beginning of June.

The horses are in their stables and receive their full allowance of hay and corn.

Labour.—Should any of the barley not have been sown during the last month, it must now, together with the grass-seeds, be sown; and if the stones have not been gathered from the new grass, this must be done.

The land planted with potatoes is to have the drills levelled by the harrows passing over them. But the main labour of this month is the preparation of the land for turnips, which is to be

done for the different kinds of turnips respectively, in the order in which they are to be sown; the first in the order of sowing being the Swedish turnips, the second the yellow turnips, and the third the white.

The land, then, intended for Swedish turnips, which had been cross-ploughed in the preceding month, is to be again ploughed, harrowed, rolled, cleaned, and made ready for being formed into drills; and the dung being applied, the seeds are sown.

The working of the other turnip-land is then to be proceeded with, so that it may be ready for being sown at the beginning of June. This land had received one ploughing in the month of April; it now receives another ploughing, and is thoroughly worked by harrowing, rolling, and gathering of weeds; and if this be not sufficient, it receives further ploughings, with such harrowing, rolling, and gathering of weeds as are sufficient to prepare it for being formed into drills.

The preparation of the land for turnips will usually occupy the month of May, and lead into the month of June, but every effort which the state of the weather allows should be used to get the land as far as possible prepared during the month of May.

In this month the operation of thrashing has become partial; and towards the middle of the month when the cattle are turned out to grass, it may be said to have nearly ceased for the season. The barn-yard of the farmer, indeed, may be generally considered to be cleared in this month, except to the extent of such stacks as may be reserved for thrashing for litter in summer, and for affording straw for thatching the new stacks when harvest arrives.

The middle of this month is the usual period for farm-servants to enter into their new situations, or change from the old. It is then, too, that the farmer will most conveniently balance his yearly accounts.

The more active period of the household dairy begins with the month of May, and continues till the end of October, when the cows are put on their winter food.

During this month the land in oats should be weeded, bands of females or young persons passing along the ridges with the weed-hook.

In the month of May, then, the following have been the principal labours of the farm:—The sheep have been kept at grass during the month, and towards the middle of it the cows and steers have been turned out to their respective fields; the fat cattle have been disposed of; the cows have received the male, and so likewise have the mares; the calves receiving milk have been turned out to their little paddock: if any barley-land has not been sown, or stones have not been gathered, it has now been done; the preparation of the turnip-land has been proceeded with, and the early-sown turnips have been sown; the potato-drills have been levelled; the corn has been weeded; the thrashing of corn has been carried on in so far as it has been necessary; and the operations of the household dairy have been attended to.

June.

Live-stock.—The cows and steers are pastured in the field during the month. All the calves will be weaned during this month, and turned out to graze for the remainder of the season. Such of the cows, heifers, and mares as have not received the male now receive him.

At the beginning of the month the horses should receive green forage, and towards the middle of it they may be put at night in the pasture-field.

At the beginning of the month the ewes with their lambs, and the ewe and wether hoggets, are at grass in their respective enclosures; and at or before the beginning of the month they are washed, and in eight days afterwards shorn.

In ten days, or as soon as convenient after shearing, the wether-hoggets, now dinmonts, and such of the ewe-hoggets, now gimmers, as are not to be retained on the farm for breeding, may be sold.

The wool which has been shorn is to be put in a dry place, and sold as soon as a market offers.

Labour.—The turnip-land, in so far as it has not been worked during the previous month, is now to be worked. As soon as it is ready to be formed into drills, the dung is to be spread and the seeds sown, the yellow turnips being the first in order of being sown, and then the white.

The potatoes are to be horse and hand hoed.

The summer-fallow is to receive its cross-ploughing, and then to be well harrowed, all weeds being carefully gathered. After this, the further working of the summer-fallow proceeds as expeditiously as the nature of the weather, and state of the labour upon the farm, allow. The turnips are to be horse and hand hoed for the first time. Lime is also being got forward to the land which is to be limed.

These, then, have been the principal operations of the month of June:—The cattle have been put to grass; the females not yet covered have received the male; the horses have been put on green forage; the sheep have been shorn, and the dinmonts, and the gimmers not reserved for breeding, have been sold; the wool has been disposed of as a market offered; the turnip-land has been worked, and the turnips have been sown, the potatoes and turnips have been horse and hand hoed; the summer-fallow has been worked, and lime got forward.

July.

Live-stock.—The whole of the cows, oxen, and weaned calves, are at grass, and are kept so during the month.

The horses continue to receive green forage during the day, and may be permitted to pasture in the fields at night; and this method of feeding may be continued during the month. But their work having become easy towards the middle of the month, their allowance of corn may be lessened.

At the commencement of the month the ewes with their lambs are in their former fields of grass; by the middle of the month the lambs are weaned; and from this time forward the lambs, now termed hogs or hoggets, are kept separate from the breeding ewes.

Labour.—In the early part of the month the hay, when ready, is mown; it is worked, put into cocks, and then put into ricks in the field; or else it is carried at once from the cocks to the stack.

In the mean time, the fallow-land is worked as the state of the weather allows. It received its first ploughing lengthwise, in April; it received its next ploughing across, immediately on the preparation of the turnip-land being finished, when it was well harrowed and worked; it is again ploughed and further harrowed and cleaned; and it is again ploughed, worked, and formed into ridges. When thus prepared, it is ready to receive the dung, which being spread is covered by a ploughing.

During this month, too, lime is brought forward to the fallow-land. It is laid in large heaps in the field to be slacked; it may be applied at the same time at which the dung is applied, or at a later period.

During the month, the turnips are again horse and hand hoed; and, by the end of the month, they may be set up by the double mould-board plough. The potatoes, too, during this month are horse and hand hoed, and by the end of the month they are set up.

These, then, have been the principal operations of the month of July:—The lambs have been weaned; the hay has been mown, worked, and placed in ricks; the fallow-land has been worked and dunged, and lime has been brought forward; and the turnips and potatoes have been horse and hand hoed.

August.

Live-stock.—The cows, steers, and calves, are at grass, and are kept so during the month.

The ewes are at grass in their own fields, and the ewe and wether hoggets in theirs. The old ewes which are to be sold may now be selected from the rest of the flock, and marked for that purpose by the marking-iron; and, at the same time, all the other sheep may have their distinguishing mark put upon them.

The horses are receiving green forage, and, when the first crop of clover is consumed, they may receive tares until the second crop is ready. They may still be allowed to remain in the fields at night.

Labour.—In so far as the working of the fallow-land has not been performed during the last month, it is now to be done. Should the turnips not have been set up during the last month, they are now to be set up.

The hay, when ready, is to be brought home to the barn-yard and stacked.

The corn now becoming ripe, preparation is to be made for thatching the stack, by forming the straw into bunches and making straw-ropes. Reapers having been engaged, the operations of the harvest are commenced and carried on in proportion as the corn is ripe. The corn that has been reaped is, as soon as it is ready, carried home to the barn-yard and stacked.

These, then, have been the principal operations during the month of August:—The cows, steers, and calves, have been kept on grass; the old ewes intended to be sold have been selected and marked, and all the sheep have been likewise marked; the labouring of the turnip-land and summer-fallow, in so far as it was not done in the preceding month, has been completed; the hay has been carried home to the barn-yard and stacked; the straw, in preparation for the thatching of the stacks, has been

got ready, and the harvest operations have been begun and proceeded with.

September.

Live-stock.—The cows, calves, and steers, are all at grass, and are kept so during the month. All the sheep are likewise at grass during the month; but before the end of it, the old ewes which had been marked for sale, may be sold.

The horses are kept on green forage. As the month advances, they are taken up from grass at night, and kept in the stable; and, at the end of the month, they are put again on hay and hard food.

Labour.—The reaping of the corn, in so far as it is not completed, proceeds with activity during this month, and it is carried home to the barn-yard as it becomes ready.

The lime, if not previously applied, is laid upon the summer-fallow land, which then receives the seed-furrow, and is sown.

These, then, have been the principal labours of the month of September:—The old ewes have been sold, and, towards the close of the month, the horses have been put on winter food; the operations of the harvest have been carried forward; lime has been applied to the fallow-land; and the wheat has been sown.

October.

Live-stock.—At the beginning of the month, the cows, calves, and steers are at grass, but as the month advances the cows may be taken up at night and receive green forage in the house.

Before the 10th of the month the rams are admitted to the ewes and gimmers.

At the commencement of the month, the ewe and wether hoggets are still at grass, but towards the end of it, when the pastures fail, they are penned on turnips.

Towards the end of the month, too, as the pastures fail, the cows, calves, and steers are put finally into their winter-houses and yards; namely, the cows into their cow-house; the calves into a yard with sheds; the year-old steers, if not ready to be finally fattened, likewise into yards with sheds; and the two-year old steers into their stalls, or into small yards and sheds; the bull into a separate yard and shed; and the colts into their yard or paddock.

Labour.—If the wheat had not been sown during the last month, it is now to be sown.

After the stubbles are cleared of corn, the operation of ploughing the stubble-land commences, and is proceeded with till all the land intended for fallow and fallow-crops is ploughed.

The cattle being put into their respective yards, the process of thrashing for fodder and provender commences, and is continued throughout the winter.

These, then, have been the principal operations of the month of October:—The male has been admitted to the ewes and gimmers; the ewe and wether hoggets have been put on turnips; the cows, calves, steers, and colts, have been put into their respective yards and stalls; the ploughing of the land to be in fallow and fallow-crops, has been carried on, and the thrashing of the corn has commenced.

The whole of this series of labours may be said to be comprehended in four periods, corresponding with the four quarters of the year,—winter, spring, summer, and autumn. The winter quarter comprehends the months of November, December, and January; the spring quarter, the months of February, March, and April; the summer quarter, May, June, and July; and the autumn quarter, August, September, and October; each of these periods being distinguished by labours peculiarly its own.

During the winter quarter, the cattle of different kinds are put into their yards, houses, and stalls, and fed on straw and tur-

nips, or other succulent food: and the horses are put on their winter provender, consisting of straw with a short allowance of corn. The breeding ewes, having previously received the male, are kept on grass, and receive hay in hard frosts and snow; and the young sheep are penned on turnips.

The main employment of the horses is ploughing the stubble-land for the next year's fallow and fallow-crops, and ploughing the grass-land, which is to be sown with oats in spring; they are further employed in taking corn to market, in bringing turnips to the stock in the yards and stalls, and, after the quarter is somewhat advanced, in carrying dung from the yards to the fields which are to be in fallow and fallow-crops.

Hedger and ditcher work, and draining and spade work of all kinds, proceed during this and the other quarters.

In the spring quarter, comprehending the months of February, March, and April, the cattle are kept in the yards with their allowance of straw and turnips, or other succulent food. The cows calve, if they have not done so in the last quarter. The ewes, when the period of lambing approaches, receive turnips; about the middle of the quarter they lamb, and are then put on new grass; and the young sheep are kept penned on turnips till April, when they are turned out to pasture for the season.

The labour of the farm now becomes active; the horses are put upon their full allowance of corn and hay; the oats are sown; the potatoes are planted; the barley and grass-seeds are sown; the land in wheat and barley, and the land in new grass, are rolled, and that intended for summer-fallow and fallow-crops receives its first spring-ploughing. During this quarter, too, the thrashing of corn is carried on; and the dung is taken from the yards.

The summer quarter comprehends the months of May, June, and July. Soon after the commencement of the quarter, the fat cattle are sold; the cows and cattle in the yards are turned out to pasture; the cows and mares that have not received the male, receive him. As the quarter advances, the calves are

weaned and turned out to graze; the sheep are washed and shorn; the young fat sheep are disposed of, and the wool is sold; and, before the conclusion of the quarter, the lambs are weaned.

The labour of this quarter commences with bringing forward any part of the spring operations not completed, and afterwards consists chiefly in working the turnip-land, in hoeing turnips and potatoes, and in preparing and manuring the summer-fallow. The hay, too, is mown and ricked. Regular thrashing ceases soon after the commencement of the quarter. The horses are put on green food; and, after the labour of tilling the turnip-land is over, they are put upon a short allowance of corn. This, too, and the following quarter, are the active season of the household dairy.

The autumn quarter comprehends the months of August, September, and October. The cattle are kept on grass during this period till towards the conclusion of it, when they are put in their houses and yards, and fed on straw and turnips, or other succulent substances. The horses, too, are put upon their winter food. The ewes are kept in their enclosures; and, about the middle of the quarter, the oldest and worst of them may be sold, their place being supplied by the younger ewes, which had been retained for that purpose; the breeding ewes receive the male; the lambs, now ewe and wether hoggets, are kept in their enclosures until the end of the quarter, when they are taken from grass and fed on turnips.

The labours of the quarter commence with bringing forward the work of the former quarter, and in securing the hay; the reaping and stacking of the corn proceed; the wheat is sown; the stubble-land is ploughed: And thus again begins the circle of the labours of the Farm.

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